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# HOT MIX RECYCLING
# DATA BANK ON MATERIAL PROPERTIES

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

# HOT MIX RECYCLING

## DATA BANK ON MATERIAL PROPERTIES

K. K. Tam
Senior Bituminous Engineer
Ministry of Transportation and Communications
Engineering Materials Office
Bituminous Section

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## ABSTRACT

Available data up to 1982 are collected from all the recycled hot mix contracts and are analysised for different properties such as % voids, % V.M.A., Marshall stability and flow, % sand and asphalt cement penetration. Also, results are compared to the different specification requirements.

The data indicate that by comparing to standard mixes, recycled hot mixes possess higher Marshall stability and flow values and generally have the following problems:

- low % air voids
- low % V.M.A.
- high sand content
- low A.C. penetration

Some recommendations are made to improve the design of recycling hot mixes and future research work is also suggested in this report.

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# HOT MIX RECYCLING - DATA BANK ON MATERIAL PROPERTIES

## INTRODUCTION

This brief report attempts to compare the material properties of recycled hot mixes with specification requirements. Data obtained from the 1981 and '82 contracts were analyzed for the five regions and then the provincial averages were determined. However, in 1981 only three regions were involved in recycling, whereas all five regions were recycling hot mixes in 1982. Therefore, the comparison of the provincial averages between the two years could be slightly distorted.

There are some 30 mixes involved in this exercise for each of the years and the 1982 tonnages for the five regions are as follows:

| | |
|---|---|
| Southwest | 129,200 tonnes |
| Central | 196,900 " |
| Eastern | 72,600 " |
| Northern | 290,100 " |
| Northwestern | 251,585 " |
| Total | 904,385 tonnes |

## RESULTS

The data of different contracts are recorded under three different sections for each of the regions,

(A) General information e.g. highway and location. A.A.D.T., quantity, recycling ratio and type of virgin aggregates (App. 1)

(B) Mix design information e.g. lift, proportion of RAP, virgin aggregate contents, % A.C., sand content, % voids, flow, stability and % V.M.A. (App. 2)

(C) Plant checks results e.g. % A.C., sand content, % voids, flow, stability, % V.M.A., B.S.G. and M.S.G. (App. 3)

## Analysis of Results

The distribution of results for the different contracts were plotted in Figs. 1-6. Also the results were analyzed for (a) average ($\bar{x}$), (b) range, (c) % in-specification, (d) % off-specification. The calculation is tabulated in Tables 1 to 5. In addition, the results were evaluated separately for surface course and binder course. In 1982, no binder course mix was laid in Eastern Region and data on one contract in the Northwestern Region was not available, hence no such data was included in this evaluation. A.C. penetration results for 1982 was not available and only the 1981 results were mentioned (Fig. 6, Table 6). The following properties were evaluated and a short discussion is made under each of the headings:

(1) % voids content (Fig. 1 & Table 1)
(2) V.M.A. (%)(Fig.2 & Table 2)
(3) Marshall stability (Fig. 3 & Table 3)
(4) Marshall flow (Fig. 4 & Table 4)
(5) % sand content (Fig. 5 & Table 5)
(6) A.C. Penetration (Fig. 6 & Table 6)

It is to be noted that the voids and V.M.A. plant checks data from the regions are not corrected for the A.C. absorption. The results are therefore higher than it would be when the A.C. absorption correction is applied to the results.

### % VOIDS (Fig. 1 and Table 1)

(A) Mix Design

(a) Average ($\bar{x}$)

Regional: - Central Region has the lowest average of the five regions for both the surface and binder courses, i.e. 2.5% and 1.5%, respectively. Two out of eight mixes were for binder courses.

- All other regions have a similar low $\bar{x}$ near to the 3% lower limit.

Provincial: - Mix designs for the surface course have maintained just slightly above the 3% limit. The same applies to 1981 binder course, but mix design $\bar{x}$ for 1982 has been below the specification limit, i.e. at 2.4% due to the low $\bar{x}$ of

Central Region. Binder course $\bar{x}$ is lower than that for the surface course.

(b) Range

Regional: - For both the surface course and binder course, the 1982 range for Central Region is below the 3% lower specification limit. The binder course range is as low as 1.2 - 2.2%.

- The ranges for the other regions and for both years have a similar spread of between 2-4%.

Provincial: - For the surface course mix design, the 1982 spread is slightly bigger than that for 1981. For the binder course, despite the lower Central Region, the 1982 range has maintained a similar spread as for 1981.

(c) % In-specification

Regional: - All mixes (i.e. 100%) were off-spec. for both the surface course and binder course for the Central Region.

- Apart from the Northern Region having maintained a 100% in-spec. rate for the surface course and improved rate (43 to 75%) for the binder course, the other Regions have lower in-spec. rate when comparing the 1982 with the 1981 data for both the surface and binder courses.

Provincial: - The overall rate for 1982 has dropped from 89% (1981) to 61% for surface course. For the binder course, the rate has increased to 45%, but except for the Northern Region, other regions have only one year data for comparison.

(B) Plant Checks (uncorrected for A.C. absorption)

(a) Average ($\bar{x}$)

Regional: - Again, Central Region has the lowest average for both the surface and binder courses. In 1982, apart from Southwestern and Central Regions, the other two regions, i.e. Eastern and Northern have surface course averages within the specification limit. Binder course averages of all the regions are all below the specification limit.

Provincial: - Comparing the two years' results, the 1982 average is slightly lower than the 1981's for both surface course and binder course. All averages are below the lower limit (i.e. 3%) of specification.

(b) Range

Regional: - The spreads for the surface course are similar for both years with the 1982 Eastern Region at a higher level and Northern Region lower. For the binder course, the Northern Region has a narrower range for 1982 than for the 1981.

Provincial: - The spread is similar for both years for the surface course but at a lower level than 1981. The 1982 binder course range has a smaller spread than that for 1981 and also at a lower level.

(c) % In-Specification

Regional: - Except for the Eastern Region that has shown an improvement in in-specification rate, the other regions show a decrease in both the surface and binder courses.

Provincial: - Only about 50% of the mixes have achieved a voids content within the specification limits for the surface course for both years. The 1982 binder course in-spec. rate is about 20%.

(C) Discussion

Comparing the mix design with plant check and the 1981 with the 1982 results, it seems that:

(i) lower % voids is obtained in the field than originally designed for. This applies to both surface and binder course and for the two years. The plant check averages for 1982 are lower than that for 1981.

(ii) as seen from the range, the variability of materials obtained at construction stage is more than that for mix design. Thus wider range is obtained for the plant checks than for the mix design. The variability seems to be similar for both years.

(iii) the lower % in-specification rate obtained at the plant checks shows that the variability of RAP may have prevented the target to be met.

(iv) the binder course has a much lower rate of % in-spec. than the surface course, i.e. 20% versus 50%, based on plant check values.

(v) it is to be noted that, when the A.C. absorption correction is applied to the results, the averages as well as the % in-spec. would be lower.

% V.M.A. (Fig. 2, Table 2)

(A) Mix Design

(a) Average ($\bar{x}$)

Regional: - The 1982 % V.M.A.'s for surface course mix designs for the Central, Eastern and Northern Regions are averaging to 13.8% while the Southwestern and Northwestern are up to the 15% level.

- For binder course mixes, Central Region has the lowest average (i.e. 12.9%) as compared with the other two regions (Southwestern and Northern).

Provincial: - Only slight change in provincial average is seen in the analysis (Table 2). 1982 surface course $\bar{x}$ is up by 0.6% and for binder course and down by 0.3% as compared with the 1981 results.

(b) Range

Regional: - The 1982 data shows that Southwestern Region has a wider range, but at a higher level than the others (i.e. 13.9 to 16.6%, 13.8 to 15.6% surface and binder courses respectively).

- Central Region has narrow range, but at a lower level (i.e. 12.5-13.5%, binder course).

- Northwestern Region has slightly higher range than Northern and Eastern Regions.

Provincial: - The 1982 ranges for surface course and binder course are larger than the 1981 values.

(c) % In-specification

Regional: - Except for Southwestern and Northwestern Region's surface and binder courses, the 1982 data show Central, Eastern and Northern Regions have mixes that all failed to meet the specifications.

Provincial: - The 1982 in-spec. rate is less that that for 1981 and both years have low rate, i.e. less than 22%.

(B) Plant Checks (uncorrected for A.C. absorption)

(a) Average ($\bar{x}$)

Regional: - Northwestern Region has a low $\bar{x}$ of 14.3 and Central Region 16.3%. Other three regions have similar $\bar{x}$ of about 15% for the 1982 surface course mixes.

- Both Northern and Eastern Regions have slightly improved 1982 $\bar{x}$ over those of 1981 for surface and binder course.

- Northwestern Region has maintained the same level for both years.

Provincial: - The 1982 $\bar{x}$'s for both binder and surface courses are slightly higher than those for 1981.

(b) Range

Regional: - For 1982 surface course mixes, the spread for Central Region is wider (e.g. 3.9%) while the other regions have a spread of about 1 to 2%.

- Northern Region has a narrower range for the 1982 surface course as compared with that for 1981 (i.e. 1.2% versus 2.7%), for binder course, it has maintained a similar range and level.

Provincial: - For both the surface and binder courses, the 1982 ranges are similar to those of 1981 but at a slightly higher level, e.g. between 13.8 to 18.2% versus 12.7 to 16.7%).

(c) % In-specification

Regional: - The 1982 plant check results for the surface course show 100% in-spec. for Central, Eastern and Northern Regions, an improvement over 1981.

- Northwestern Region has poorer 1982 in-spec. rate than the 1981 (i.e. 0% (N=4) versus 92% (N=12)).

- The 1982 Northern Region results show improvement over that for 1981 (75% versus 50% in-spec.)

Provincial: - While the surface course 1982 in-spec. rate shows a slight drop as compared with the 1982 value, the binder course has increased by the same amount, (e.g. by 8%) in 1982.

(C) Discussion

Comparing the mix design with the plant checks and the 1981 with 1982 results, it seems that:

(i) difficulty still experienced in 1982 in designing mixes to meet V.M.A. requirement.

(ii) the 1981 and 1982 ranges for both surface course mix design and plant checks are similar but the 1982 range is at a slightly higher level, i.e. an improvement over 1981.

(iii) although the 1982 provincial results for binder course show a wider range at the mix design stage, the plant checks show that there is the same spread as for 1981.

(iv) although the mix designs for both surface and binder courses have very low in-spec. rate (<22%), the plant checks rates are much higher (i.e. >60%). However, these rates would be lower if the A.C. absorption is able to be applied to the V.M.A. plant check results.

MARSHALL STABILITY (Fig. 3, Table 3)

Mix Design and Plant Checks

(a) Average ($\bar{x}$)

Regional: - All regions have achieved high $\bar{x}$ of stability for both years.

- In general, binder course $\bar{x}$'s are higher than the surface course $\bar{x}$'s.

Provincial: - $\bar{x}$'s for both years are similar, e.g. about 12000N and 14500N for mix design and plant checks respectively.

- Plant check $\bar{x}$'s are higher than that for mix design for both the surface and binder courses.

(b) Range

Regional: - For 1982 surface course mix design results, Northern Region has the largest spread (i.e. some 9400N), followed by Southwestern Region (8400N). Ranges of binder courses for the other regions are less than 4000N.

- The ranges for plant checks show less than 6000N spread for all regions, i.e. narrower than the mix design ranges.

Provincial: - Except the larger range for the mix design of surface course, the other 1982 ranges i.e. for plant checks and binder course, are similar to that for 1981.

- The mix des gn ranges of 1982 are larger than that of the plant checks for both the surface and binder courses.

- The 1981 ranges for mix design are very close to that for the plant checks for both the surface and binder courses.

(c) % In-specification

Regional and Provincial:

- All mixes are in-spec. (i.e. 100%) for both years and for both plant checks and mix design.

(d) Discussion

(i) Comparing the mix design and plant checks, higher plant check $\bar{x}$'s are obtained. This could be due to the difference in compaction of Marshall briquettes (e.g. hand versus machine) and harsher mixes obtained during plant mixing.

(ii) The larger range for the 1982 Northern Region results tends to suggest that the RAP materials of different contracts were more variable than the other Regions.

(iii) The results show that all mixes have no difficulty in meeting stability requirement.

FLOW (Fig. 4, Table 4)

Mix Design and Plant Checks

(a) Average ($\bar{x}$)

Regional: - All regions have $\bar{x}$'s above the 10 min. for both years except the 1982 x for Eastern Region which is 8.1.

Provincial: - In general, the 1982 binder course $\bar{x}$'s are higher than that for surface course, where as the 1981 results show a slight reverse.

(b) Range

Regional: - Except the 1982 mix design range for Central Region, the other Regions seem to have a range of less than 5 units spread, especially the Northern and Northwestern Regions.

Provincial: - Except for the surface course mix design, other 1982 ranges are similar to those for the 1981.

(c) % In-specification

Regional: - Except for the 1982 Eastern Region and Northwestern Region mix design surface course results, the other Regions seem to have high % of in-spec. rate (e.g. 67%).

Provincial: - More than 73% in-spec. rate has been achieved for both years and for the surface and binder courses.

(d) Discussion

(i) Generally, mixes with higher flow seem to have the corresponding higher stability.

(ii) Northern and Northwestern Regions seem to have less variation with the flow (i.e. smaller range) than the other Regions.

% SAND (Fig. 5, Table 5)

Mix Design and Plant Checks

(a) Average ($\bar{x}$)

Regional: - Southwestern Region has the highest $\bar{x}$ of sand content in the mixes, i.e. about 63% for both surface and binder courses.

- This is followed by Northern and Northwestern Regions, i.e. about 60%.

- Central and Eastern Regions have the lowest $\bar{x}$'s (only 2 contracts for Eastern Region).

Provincial: - The averages for both years and for both surface and binder courses are similar, e.g. about 60%

(b) Range

Regional: - The spread of the ranges appears to be similar for the five Regions when comparing the two years' results (spread between 3% to 8%).

- Plant check ranges are slightly larger than mix designs for both the surface and binder courses.

Provincial: - Ranges between the two years for surface and binder courses are similar e.g. between 50 to 65 %.

(c) % In-specification

Regional: - Southwestern Region has 0% in-spec. for the surface course and about 40% in-spec. for binder course mixes of mix design and plant checks.

- Central Region has 100% in-spec. for mix design of binder course, and 50% in-spec. for the plant checks.

- Northwestern Region has 86% in-spec. for mix design of surface course and 75% in-spec. rate is achieved at plant checks.

Provincial: - Similar rate is obtained for the 1982 surface course mix designs and plant checks, i.e. about 70%.

- Lower plant checks in-spec. rate is obtained for the 1982 binder course than that of the mix designs.

- For the two years, the plant checks in-spec. rate shows an improvement over 1981 for both the surface and binder courses.

(d) Discussion

(i) Although the averages show little change in the % sand content between the two years, the plant checks in-spec. rate has actually improved. It shows that effort has been made to improve the sand content by using, for example, separate stone and cleaner blending sand as virgin aggregates.

(ii) It seems that more fines were obtained in the mixes during the construction stage than that for the mix designs. About 2% above or below the mix design range is observed.

(iii) Generally, about 60% of the in-spec. rate of mix design is obtained for the plant checks.

## ASPHALT CEMENT PENETRATION

The lower than desired A.C. penetrations of recycled mixes has been seen to be a concern from the 1981 results. Fig. 6 shows virtually all contracts have A.C. penetrations below the desirable levels. In view of the similar operation between the 1981 and 1982 hot mix recycling, the problem of low A.C. penetration would be expected to remain in 1982.

Since low A.C. penetration is related to the aging of the materials, we are therefore getting an aged pavement as a result. The cause of the problem is due to the inability of the virgin asphalt to soften the old A.C. in the RAP. This is in turn affected by high recycling ratio and hardening of A.C. in the mixing process. To improve the A.C. penetration, three types of rejuvenating/recycling agents have been experimented, one in 1980 and two in 1982. Results of these three trials are forthcoming.

The effect of recycling ratio on the obtainable A.C. penetration of recycled mixes can be seen from the analysis in Table 6. By using "one grade softer" A.C., the percentage of desired penetration of A.C. recovered from recycled mixes has increased by 15% (i.e. from 63% to 78% for recycling ratio of 70:30 and 60:40 respectively). With a "two grade softer" A.C., the percentage has increased to 117%, although this is only a single data at 70:30 recycling ratio.

In reviewing the A.C. penetration data (Table 7) an attempt was made to predict the A.C. penetration of recycled hot mixes. The following formula is developed:

$$\log Pp = x \log Po + y \log (0.6\ Pn)$$

where Pp - predicted A.C. penetration of recycled hot mix
Po - penetration of A.C. recovered from the RAP
Pn - penetration of new A.C. added to their recycled hot mix
x - proportion of RAP in the mix
y - proportion of virgin aggregate in the mix

Note: A factor of 0.6 is introduced to the Pn as experience shows that about 60% retained penetration is obtained with A.C. after going through the heating and mixing process in the plant. No multiplying factor is given to Po because further hardening of A.C. in the RAP is not expected to be significant after plant mixing.

Based on the formula, the predicted values were calculated (in Table 7) and a regression analysis was made on the results with the actual penetration of A.C. obtained from the recycled hot mixes (Pr). The analysis shows that there is good correlation (coefficient r = 0.75) between the predicted and the actual penetrations.

SUMMARY

(1) Low voids content remains as a trend in the 1982 results. Only 32% of the mixes at the plant checks has met the voids specification requirement (Fig. 7).

(2) Although, plant check results show that higher in-spec. rate is obtained the V.M.A. plant check results have not been corrected for A.C. absorption. Thus lower in-spec. rate could be expected when A.C. absorption is taken into account. Despite this, it appears that similar level of in-spec. rate is obtained for both years based on the plant check results (Figure 7).

(3) Stability and flow of recycled hot mixes tends to be consistently higher than conventional mixes. This is due to the use of aggregates with increased harshness after the crushing process and old A.C. in the RAP. Because of this, at high recycling ratio (e.g. 70:30), mixes tend to be difficult to compact. Also, these type of mixes may be brittle and subject to more frequent cracks as caused by thermal change and ground movement.

(4) High sand content continues to be the mix property as seen in the 1982 results. However, the results show efforts have been made to get the sand content in the correct proportion. There are several drawbacks for having too high a sand content in a mix, e.g.
   (a) lower surface texture resulting in reducing the skid resistance of a surface course.
   (b) higher A.C. demand leading to drier mixes and lower density.

(5) Low A.C. penetration of recycled mixes remains a problem in that aged pavements are obtained. In order to improve the A.C. penetration, three types of rejuvenating/recycling agents were experimented and results are forthcoming.

(6) A formula is developed to predict the A.C. penetration of recycled hot mixes. The predicted values appear to correlate well with the results obtained from field mixes.

## RECOMMENDATION

It appears that all parties involved in the recycling hot mix process have gained more experience and better understanding of the shortcomings. However, the following is recommended if the cost can be balanced by benefits:

(1) In respect to virgin aggregates, separate H.L. stone and blending sand should be prepared to be used. This is seen to be fruitful from some 1982 contracts that both % voids and V.M.A. results were abe to be improved.

(2) Close monitoring and frequent testing at all stages of mix design and construction is necessary in order that consistent products are obtained. Rapid modification to mixes can also be possible with the testing data.

(3) Lower recycling ratios should be considered in view of the difficulty in obtaining the desirable mix properties.

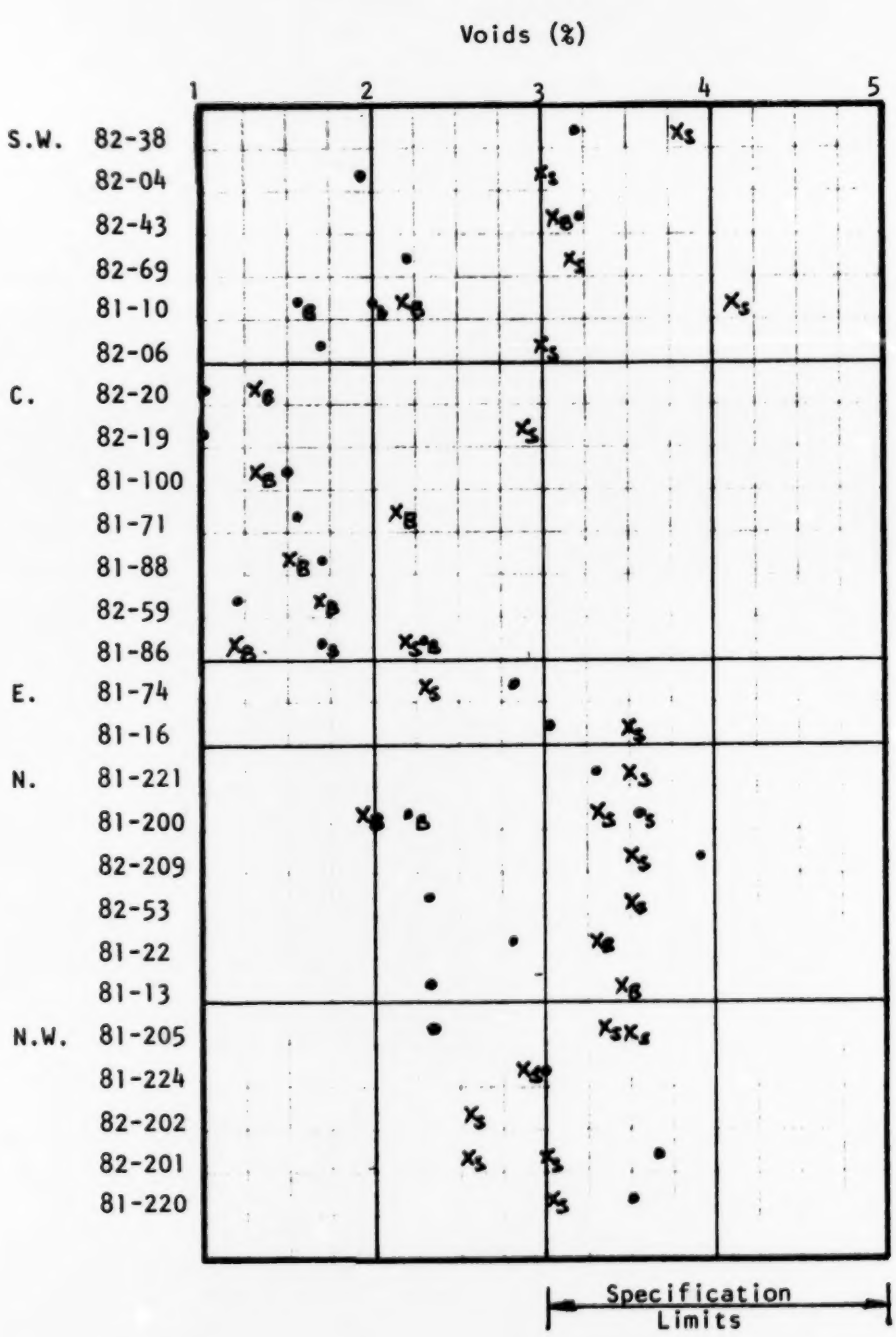
(4) Increase the use of recycling agents and modifiers and/or lower the recycling ratio should be considered for improving the A.C. penetration characteristics of recycled mixes.

(5) Continue evaluation of data bank until such stage that the situation warrants the discontinuation of such exercise i.e. no new development in hot mix recycling technology and that satisfactory mix designs are obtained.

(6) Research work should be initiated to evaluate the accelerated performance of recycled hot mixes in the laboratory.

TABLE 1: ANALYSIS OF AIR VOIDS (%)
(SPEC. 3-5%)

| Type | Region | Average (x̄) | | Range | | % In-spec. | | % Off-spec. | | No. of Mixes Monitored | | Lift |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | |
| Mix Design | S.W. | - | 3.4 | - | 3.0-4.2 | - | 100 | - | 0 | - | 5 | Surface |
| | C. | - | 2.5 | - | 2.2-2.8 | - | 0 | - | 100 | - | 2 | |
| | E. | 3.0 | 2.9 | 2.4-3.6 | 2.3-3.5 | 67 | 50 | 33 | 50 | 3 | 2 | |
| | N. | 3.2 | 3.5 | 3.0-3.6 | 3.3-3.5 | 100 | 100 | 0 | 0 | 5 | 5 | |
| | N.W. | 3.3 | 3.0 | 3.0-3.7 | 2.6-3.5 | 100 | 57 | 0 | 43 | 12 | 7 | |
| | Prov'l | 3.2 | 3.1 | 2.4-3.7 | 2.2-4.2 | 89 | 61 | 11 | 39 | 20 | 21 | |
| | S.W. | - | 2.7 | - | 2.2-3.1 | - | 50 | - | 50 | - | 2 | Binder |
| | C. | - | 1.5 | - | 1.2-2.2 | - | 0 | - | 100 | - | 6 | |
| | E. | 2.9 | - | 2.9 | - | 0 | - | 100 | - | 1 | 0 | |
| | N. | 2.9 | 3.0 | 2.1-3.2 | 1.9-3.4 | 43 | 75 | 57 | 25 | 7 | 4 | |
| | N.W. | 3.1 | - | 2.3-4.0 | - | 57 | - | 43 | - | 7 | 0 | |
| | Prov'l | 3.0 | 2.4 | 2.1-4.0 | 1.2-3.4 | 33 | 45 | 67 | 55 | 15 | 12 | |
| Plant Checks | S.W. | - | 2.2 | - | 1.7-3.2 | - | 20 | - | 80 | - | 5 | Surface |
| | C. | - | 1.4 | - | 1.0-1.7 | - | 0 | - | 100 | - | 2 | |
| | E. | 2.0 | 3.0 | 1.9-2.1 | 2.8-3.1 | 0 | 50 | 100 | 50 | 2 | 2 | |
| | N. | 3.5 | 3.4 | 3.0-4.8 | 2.3-4.0 | 100 | 80 | 0 | 20 | 7 | 5 | |
| | N.W. | 3.0 | 3.1 | 1.7-3.7 | 2.3-3.7 | 58 | 75 | 42 | 25 | 12 | 4 | |
| | Prov'l | 2.8 | 2.6 | 1.7-4.8 | 1.0-4.0 | 53 | 45 | 47 | 55 | 21 | 18 | |
| | S.W. | - | 2.3 | - | 1.6-3.2 | - | 33 | - | 67 | - | 3 | Binder |
| | C. | - | 1.5 | - | 1.0-2.3 | - | 0 | - | 100 | - | 6 | |
| | E. | 2.3 | - | 2.3 | - | 0 | - | 100 | - | 1 | 0 | |
| | N. | 3.1 | 2.7 | 2.2-5.4 | 2.2-3.3 | 50 | 25 | 50 | 75 | 6 | 4 | |
| | N.W. | 3.0 | - | 2.5-3.6 | - | 33 | - | 67 | - | 3 | 0 | |
| | Prov'l | 2.8 | 2.2 | 2.2-5.4 | 1.0-3.3 | 28 | 19 | 72 | 81 | 10 | 13 | |




x = Mix Design
● = Plant Checks
s = Surface Course
B = Binder Course

Fig. 1

TABLE 2: ANALYSIS OF V.M.A. (%) RESULTS
(SPEC. BETWEEN 14-16%)

| Type | Region | Average (%) | | Range | | % In-spec. | | % Off-spec. | | No. of Mixes Monitored | | Lift |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | |
| Mix Design | S.W. | - | 15.2 | - | 13.9-16.6 | - | 20 | - | 80 | - | 5 | Surface |
| | C. | - | 13.8 | - | 13.8 | - | 0 | - | 100 | - | 1 | |
| | E. | 12.7 | 13.9 | 12.7 | 13.3-14.4 | 0 | 0 | 100 | 100 | 2 | 2 | |
| | N. | 13.8 | 13.8 | 12.9-14.9 | 13.3-14.5 | 50 | 0 | 50 | 100 | 4 | 4 | |
| | N.W. | 14.6 | 14.7 | 14.2-15.6 | 13.5-15.4 | 8 | 33 | 92 | 67 | 12 | 6 | |
| | Prov'l | 13.7 | 14.3 | 12.7-15.6 | 13.3-16.6 | 19 | 11 | 81 | 89 | 18 | 18 | |
| | S.W. | - | 14.7 | - | 13.8-15.6 | - | 50 | - | 50 | - | 2 | Binder |
| | C. | - | 12.9 | - | 12.5-13.5 | - | 0 | - | 100 | - | 5 | |
| | E. | 14.0 | - | 14.0 | - | 0 | - | 100 | - | 1 | 0 | |
| | N. | 14.3 | 14.0 | 13.6-14.9 | 13.4-14.7 | 67 | 0 | 33 | 100 | 3 | 4 | |
| | N.W. | 14.4 | - | 13.5-15.1 | - | 0 | - | 100 | - | 7 | 0 | |
| | Prov'l | 14.2 | 13.9 | 13.5-15.1 | 12.5-15.6 | 22 | 17 | 78 | 83 | 11 | 11 | |
| Plant Checks | S.W. | - | 15.5 | - | 14.7-16.6 | - | 40 | - | 60 | - | 5 | Surface |
| | C. | - | 16.3 | - | 14.3-18.2 | - | 100 | - | 0 | - | 2 | |
| | E. | 14.5 | 15.0 | 14.1-14.9 | 14.8-15.1 | 50 | 100 | 50 | 0 | 2 | 2 | |
| | N. | 15.4 | 15.6 | 14.2-16.9 | 14.9-16.1 | 86 | 100 | 14 | 0 | 7 | 5 | |
| | N.W. | 14.4 | 14.3 | 12.7-15.5 | 13.8-14.9 | 92 | 0 | 8 | 100 | 12 | 4 | |
| | Prov'l | 14.8 | 15.3 | 12.7-16.9 | 13.8-18.2 | 76 | 68 | 23 | 32 | 21 | 18 | |
| | S.W. | - | 15.8 | - | 15.1-16.5 | - | 50 | - | 50 | - | 2 | Binder |
| | C. | - | 14.6 | - | 13.8-15.4 | - | 83 | - | 17 | - | 6 | |
| | E. | 15.4 | - | 15.4 | - | 100 | - | 0 | - | 1 | 0 | |
| | N. | 15.0 | 15.2 | 14.2-15.7 | 14.2-16.0 | 50 | 75 | 50 | 25 | 6 | 4 | |
| | N.W. | 14.4 | - | 13.2-16.0 | - | 33 | - | 67 | - | 3 | 0 | |
| | Prov'l | 14.9 | 15.2 | 13.2-16.0 | 13.8-16.5 | 61 | 69 | 39 | 31 | 10 | 12 | |

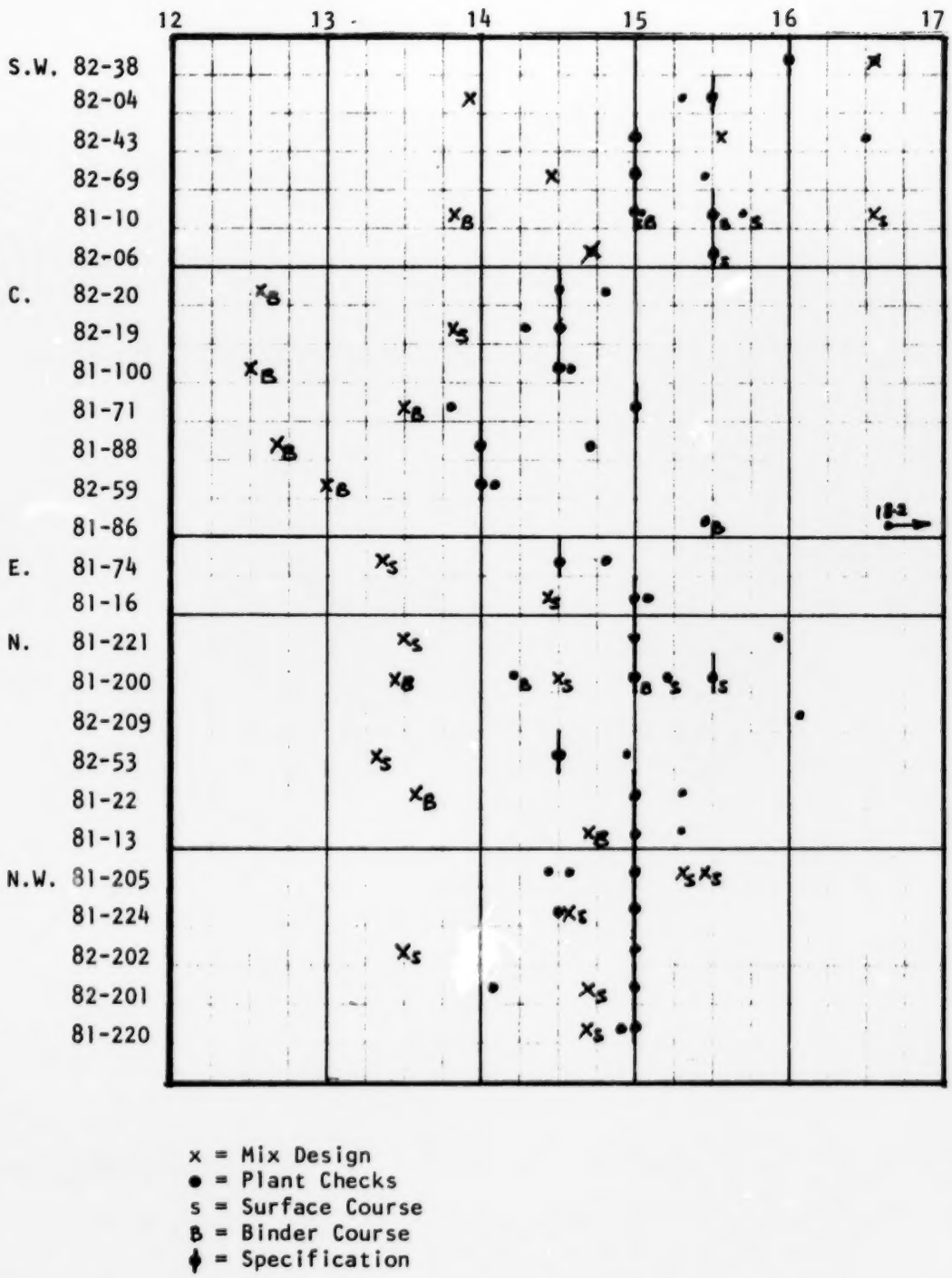
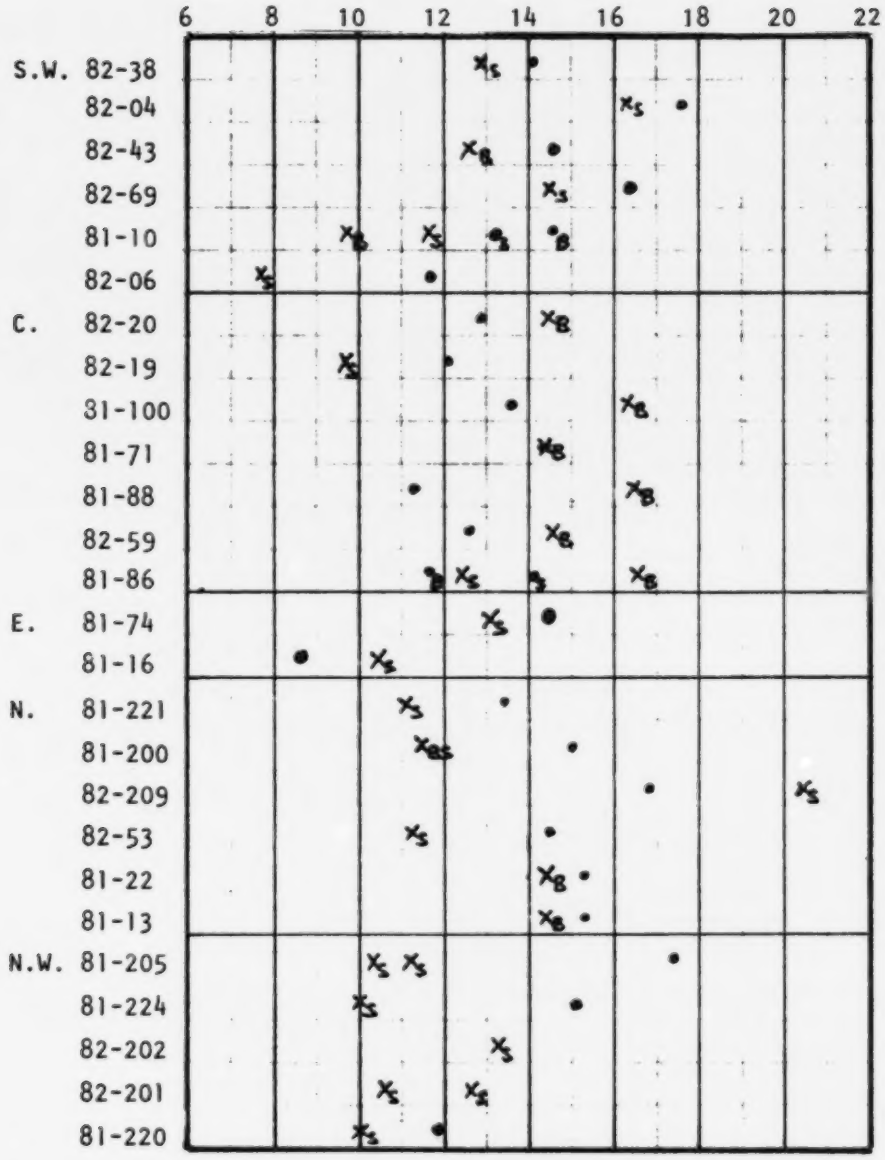

V.M.A. (%)
12
13
14
15
16
17
S.W. 82-38
82-04
82-43
82-69
81-10
82-06
C. 82-20
82-19
81-100
81-71
81-88
82-59
81-86
E. 81-74
81-16
N. 81-221
81-200
82-209
82-53
81-22
81-13
N.W. 81-205
81-224
82-202
82-201
81-220
x = Mix Design
● = Plant Checks
s = Surface Course
B = Binder Course
♦ = Specification

Fig. 2

TABLE 3: ANALYSIS OF MARSHALL STABILITY RESULTS
(X1000N, VARIABLE, 4400N MIN. TO 8900N MIN.)

| Type | Region | Average (Ẍ) | | Range | | % In-spec. | | % Off-spec. | | No. of Mixes Monitored | | Lift |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | |
| Mix Design | S.W. | - | 12.7 | - | 7.8-16.3 | - | 100 | - | 0 | - | 5 | Surface |
| | C. | - | 11.2 | - | 9.8-12.5 | - | 100 | - | 0 | - | 2 | |
| | E. | 13.9 | 11.8 | 12.1-15.6 | 10.5-13.1 | 100 | 100 | 0 | 0 | 3 | 2 | |
| | N. | 11.7 | 13.6 | 10.6-13.1 | 11.1-20.5 | 100 | 100 | 0 | 0 | 5 | 5 | |
| | N.W. | 12.6 | 11.1 | 8.9-16.5 | 10.0-13.3 | 100 | 100 | 0 | 0 | 12 | 7 | |
| | Prov'l | 12.7 | 12.1 | 8.9-16.5 | 7.8-20.5 | 100 | 100 | 0 | 0 | 20 | 21 | |
| | S.W. | - | 11.3 | - | 9.8-12.7 | - | 100 | - | 0 | - | 2 | Binder |
| | C. | - | 15.5 | - | 14.4-16.7 | - | 100 | - | 0 | - | 6 | |
| | E. | 10.8 | - | 10.8 | - | 100 | - | 0 | - | 1 | 0 | |
| | N. | 11.4 | 13.2 | 10.1-12.7 | 11.5-14.5 | 100 | 100 | 0 | 0 | 7 | 4 | |
| | N.W. | 13.0 | - | 9.6-16.6 | - | 100 | - | 0 | - | 7 | 0 | |
| | Prov'l | 11.7 | 13.3 | 9.6-16.6 | 9.8-16.7 | 100 | 100 | 0 | 0 | 15 | 12 | |
| Plant Checks | S.W. | - | 14.6 | - | 11.8-17.7 | - | 100 | - | 0 | - | 5 | Surface |
| | C. | - | 13.1 | - | 12.1-14.1 | - | 100 | - | 0 | - | 2 | |
| | E. | 13.8 | 11.6 | 13.1-14.5 | 8.7-14.5 | 100 | 100 | 0 | 0 | 2 | 2 | |
| | N. | 14.0 | 14.9 | 11.2-17.2 | 13.5-16.9 | 100 | 100 | 0 | 0 | 7 | 5 | |
| | N.W. | 14.2 | 14.8 | 8.6-16.7 | 12.0-17.4 | 100 | 100 | 0 | 0 | 12 | 3 | |
| | Prov'l | 14.0 | 13.8 | 8.6-17.2 | 8.7-17.7 | 100 | 100 | 0 | 0 | 21 | 17 | |
| | S.W. | - | 15.1 | - | 14.6-16.0 | - | 100 | - | 0 | - | 3 | Binder |
| | C. | - | 12.7 | - | 11.2-14.4 | - | 100 | - | 0 | - | 6 | |
| | E. | 13.3 | - | 13.3 | - | 100 | - | 0 | - | 1 | 0 | |
| | N. | 15.0 | 15.4 | 10.0-16.6 | 15.0-15.9 | 100 | 100 | 0 | 0 | 6 | 4 | |
| | N.W. | 15.3 | - | 13.2-17.1 | - | 100 | - | 0 | - | 3 | 0 | |
| | Prov'l | 14.5 | 14.4 | 10.0-17.1 | 11.2-16.0 | 100 | 100 | 0 | 0 | 10 | 13 | |




x = Mix Design
● = Plant Checks
s = Surface Course
B = Binder Course

Fig. 3

TABLE 4: ANALYSIS OF MARSHALL FLOW RESULTS
(SPEC. 10 MIN. X 0.25 mm)

| Type | Region | Average (x̄) | | Range | | % In-spec. | | % Off-spec. | | No. of Mixes Monitored | | Lift |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | |
| Mix Design | S.W. | - | 12.4 | - | 10.2-13.8 | - | 100 | - | 0 | - | 5 | Surface |
| | C. | - | 18.8 | - | 10.2-27.4 | - | 100 | - | 0 | - | 2 | |
| | E. | 14.3 | 10.1 | 13.0-16.7 | 8.7-11.5 | 100 | 50 | 0 | 50 | 3 | 2 | |
| | N. | 11.8 | 11.5 | 10.8-12.4 | 9.7-13.7 | 100 | 90 | 0 | 10 | 5 | 5 | |
| | N.W. | 10.7 | 10.9 | 8.2-16.0 | 8.3-12.8 | 75 | 57 | 25 | 43 | 12 | 7 | |
| | Prov'l | 12.3 | 12.7 | 8.2-16.7 | 8.3-27.4 | 92 | 79 | 8 | 21 | 20 | 21 | |
| | S.W. | - | 15.2 | - | 12.3-18.0 | - | 100 | - | 0 | - | 2 | Binder |
| | C. | - | 15.8 | - | 11.1-18.4 | - | 100 | - | 0 | - | 6 | |
| | E. | 10.6 | - | 10.6 | - | 100 | - | 0 | - | 1 | 0 | |
| | N. | 12.7 | 13.0 | 11.8-13.5 | 12.7-14.7 | 100 | 100 | 0 | 0 | 7 | 4 | |
| | N.W. | 11.0 | - | 8.6-14.6 | - | 57 | - | 43 | - | 7 | 0 | |
| | Prov'l | 11.4 | 14.7 | 8.6-14.6 | 11.1-18.4 | 86 | 100 | 14 | 0 | 15 | 12 | |
| Plant Checks | S.W. | - | 12.0 | - | 10.9-13.5 | - | 100 | - | 0 | - | 5 | Surface |
| | C. | - | 17.1 | - | 14.2-19.9 | - | 100 | - | 0 | - | 2 | |
| | E. | 16.5 | 8.1 | 13.7-19.2 | 7.9-8.3 | 100 | 0 | 0 | 100 | 2 | 2 | |
| | N. | 11.4 | 11.6 | 9.5-13.2 | 10.3-13.3 | 86 | 100 | 14 | 0 | 7 | 5 | |
| | N.W. | 10.5 | 11.2 | 7.8-13.3 | 8.7-13.7 | 67 | 67 | 33 | 33 | 12 | 3 | |
| | Prov'l | 12.8 | 12.0 | 7.8-19.2 | 7.9-19.9 | 84 | 73 | 16 | 27 | 21 | 17 | |
| | S.W. | - | 13.6 | - | 11.9-16.8 | - | 100 | - | 0 | - | 3 | Binder |
| | C. | - | 16.2 | - | 14.2-17.9 | - | 100 | - | 0 | - | 6 | |
| | E. | 13.6 | - | 13.6 | - | 100 | - | 0 | - | 1 | 0 | |
| | N. | 13.8 | 12.4 | 13.0-14.6 | 11.0-13.5 | 100 | 100 | 0 | 0 | 6 | 4 | |
| | N.W. | 10.2 | - | 8.6-12.4 | - | 33 | - | 67 | - | 3 | 0 | |
| | Prov'l | 12.5 | 14.1 | 8.6-14.6 | 11.0-17.9 | 78 | 100 | 22 | 0 | 10 | 13 | |

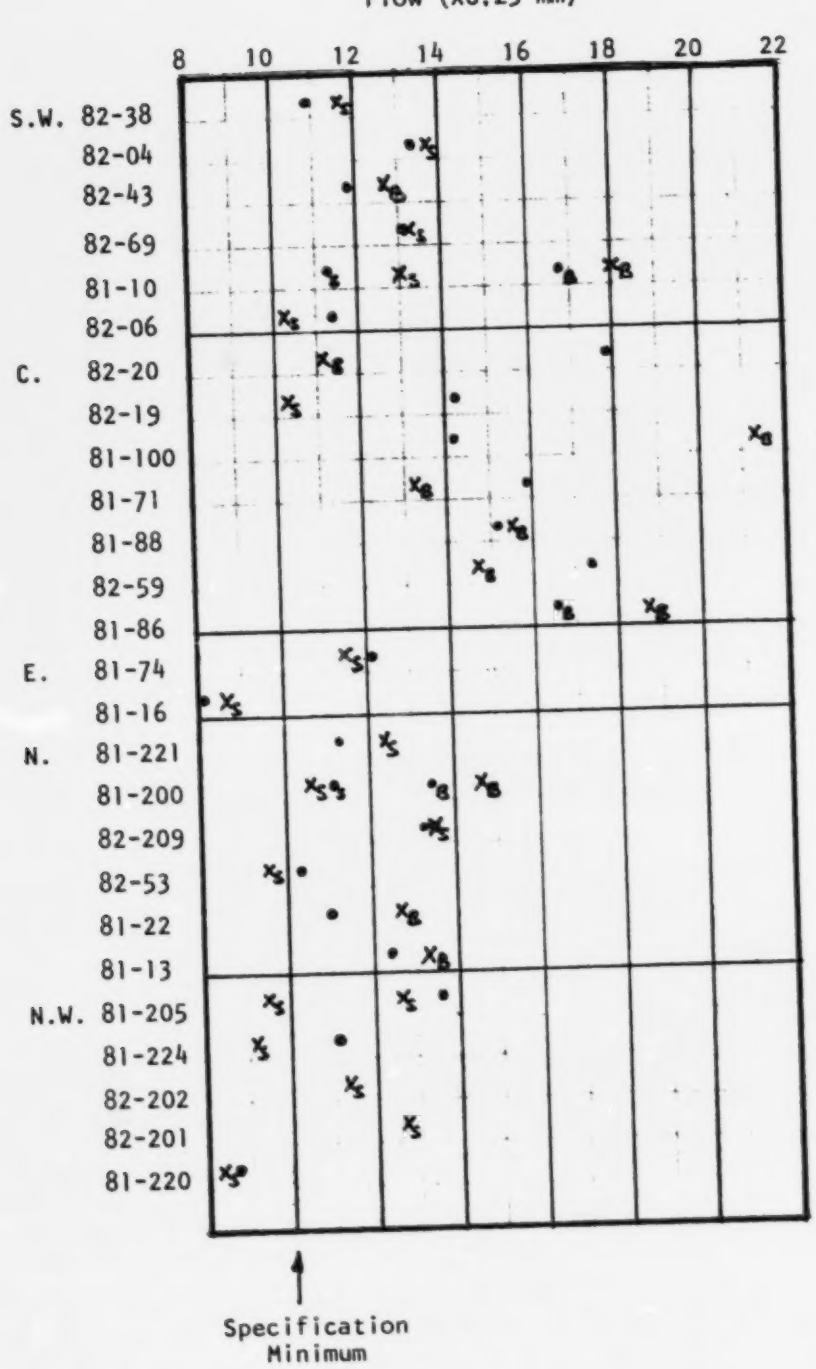

Flow (X0.25 mm)
8
10
12
14
16
18
20
22
S.W. 82-38
82-04
82-43
82-69
81-10
82-06
C. 82-20
82-19
81-100
81-71
81-88
82-59
81-86
E. 81-74
81-16
N. 81-221
81-200
82-209
82-53
81-22
81-13
N.W. 81-205
81-224
82-202
82-201
81-220
Specification Minimum
x = Mix Design
● = Plant Checks
s = Surface Course
ß = Binder Course

Fig. 4

TABLE 5: ANALYSIS OF SAND CONTENT (%) RESULTS
(SPEC. HL-1 = 55%, HL-3 + 4 = 55 TO 60%,
HL-8 UP TO 55%)

| Type | Region | Average (%) | | Range | | % In-spec. | | % Off-spec. | | No. of Mixes Monitored | | Lift |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | |
| Mix Design | S.W. | - | 63.5 | - | 62.4-65.0 | - | 0 | - | 100 | - | 5 | Surface |
| | C. | - | 55.0 | - | 55.0 | - | 100 | - | 0 | - | 2 | |
| | E. | 57.3 | 56.0 | 57.0-59.0 | 54.0-58.0 | 100 | 100 | 0 | 0 | 3 | 2 | |
| | N. | 58.3 | 59.8 | 56.0-65.0 | 57.0-64.0 | 86 | 60 | 14 | 40 | 7 | 5 | |
| | N.W. | 60.0 | 59.6 | 60.0-62.0 | 55.0-60.0 | 100 | 86 | 0 | 14 | 15 | 7 | |
| | Prov'l | 58.5 | 58.8 | 56.0-65.0 | 54.0-65.0 | 95 | 69 | 5 | 31 | 25 | 21 | |
| | S.W. | - | 61.9 | - | 58.0-65.8 | - | 50 | - | 50 | - | 2 | Binder |
| | C. | - | 56.0 | - | 50.0-60.0 | - | 100 | - | 0 | - | 6 | |
| | E. | 57.0 | - | 57.0 | - | 100 | - | 0 | - | 1 | 0 | |
| | N. | 58.9 | 59.0 | 57.0-64.0 | 58.0-60.0 | 71 | 100 | 29 | 0 | 7 | 4 | |
| | N.W. | 62.6 | - | 60.0-65.0 | - | 43 | - | 57 | - | 7 | 0 | |
| | Prov'l | 59.5 | 59.0 | 57.0-65.0 | 50.0-65.8 | 71 | 83 | 29 | 17 | 15 | 12 | |
| Plant Checks | S.W. | - | 63.3 | - | 61.3-66.4 | - | 0 | - | 100 | - | 5 | Surface |
| | C. | - | 54.7 | - | 53.2-56.1 | - | 100 | - | 0 | - | 2 | |
| | E. | 56.3 | 56.7 | 54.3-58.2 | 55.8-57.5 | 100 | 100 | 0 | 0 | 2 | 2 | |
| | N. | 60.0 | 58.9 | 55.3-62.6 | 55.1-62.3 | 43 | 80 | 57 | 20 | 7 | 5 | |
| | N.W. | 56.5 | 62.3 | 58.1-64.5 | 58.9-65.6 | 17 | 75 | 83 | 25 | 12 | 4 | |
| | Prov'l | 57.6 | 59.2 | 54.3-64.5 | 53.2-66.4 | 53 | 71 | 47 | 29 | 21 | 18 | |
| | S.W. | - | 63.3 | - | 59.0-65.7 | - | 33 | - | 67 | - | 3 | Binder |
| | C. | - | 56.2 | - | 53.1-59.9 | - | 50 | - | 50 | - | 6 | |
| | E. | 61.1 | - | 61.1 | - | 0 | - | 100 | - | 1 | 0 | |
| | N. | 62.6 | 60.1 | 56.3-66.2 | 58.3-62.8 | 17 | 75 | 83 | 25 | 6 | 4 | |
| | N.W. | 64.6 | - | 64.0-65.7 | - | 0 | - | 100 | - | 3 | 0 | |
| | Prov'l | 62.8 | 59.9 | 56.3-66.2 | 53.1-65.7 | 6 | 53 | 94 | 47 | 10 | 13 | |

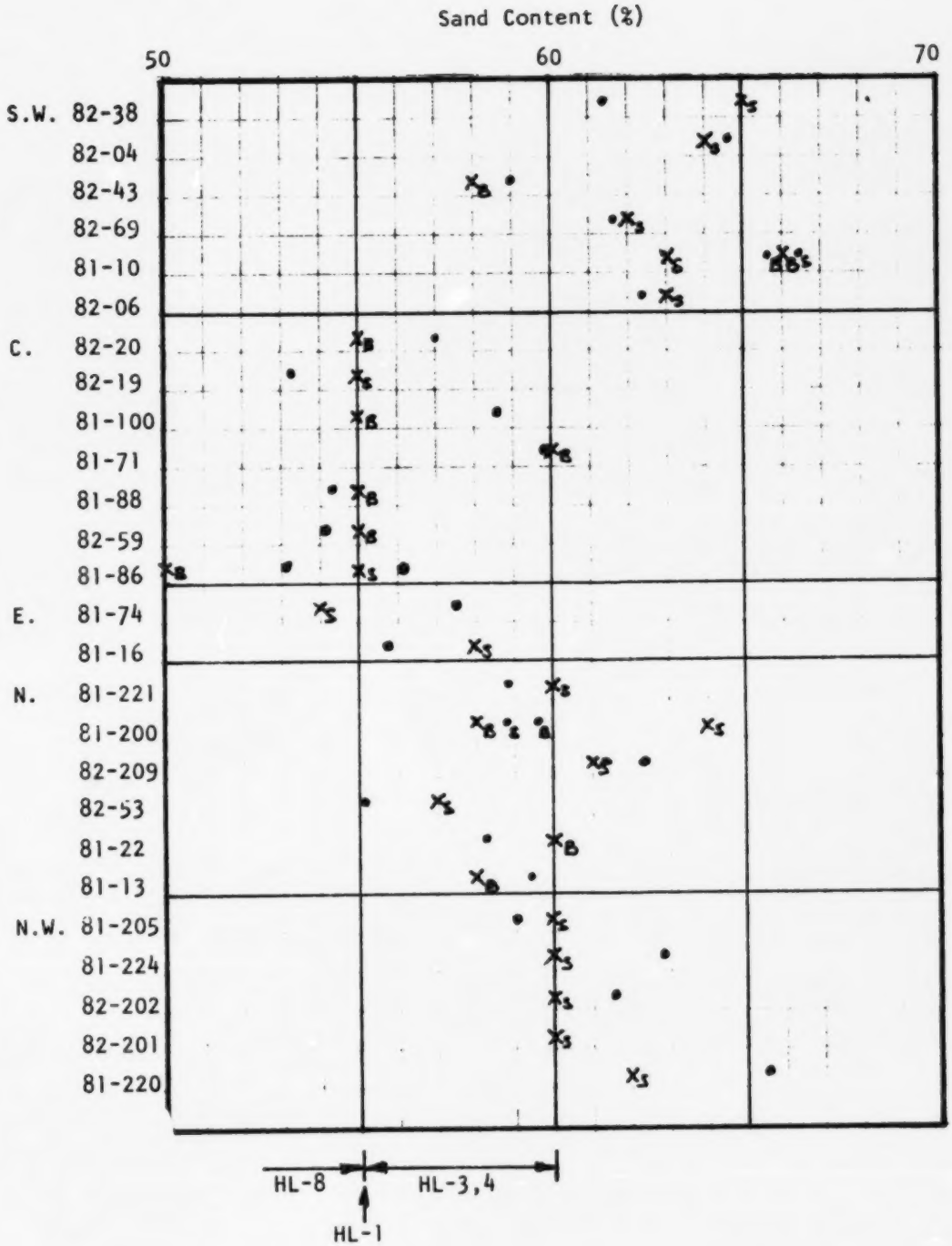

Sand Content (%)
50
60
70
S.W. 82-38
82-04
82-43
82-69
81-10
82-06
C. 82-20
82-19
81-100
81-71
81-88
82-59
81-86
E. 81-74
81-16
N. 81-221
81-200
82-209
82-53
81-22
81-13
N.W. 81-205
81-224
82-202
82-201
81-220
HL-8
HL-3,4
HL-1
x = Mix Design
● = Plant Checks
s = Surface Course
ʙ = Binder Course

Fig. 5

TABLE 6: A.C. Penetration of Recycled Hot Mixes

| Contract | Region | New A.C. Pen. | A.C. Grade for Virgin Resurfacing Mix | # of "Grade Softer" | Pen. of Recycled Mix (a) | Desired Pen. (b) | % of Desired Pen. |
|---|---|---|---|---|---|---|---|
| 70:30 Recycling Ratio | | | | | | | |
| 80-219 | NW | 291 | 150/200 | 1 | 49 | 90 | 54 |
| 79-89 | NW | 290 | 150/200 | 1 | 66 | 90 | 73 |
| 80-225 | N | 281 | 150/200 | 1 | 68 | 90 | 76 |
| 80-226 | N | 324 | 150/200 | 1 | 46 | 90 | 51 |
| 81-229 | N | 286 | 150/200 | 1 | 53 | 90 | 59 |
| 80-202 | N | 347 | 150/200 | 1 | 39 | 90 | 43 |
| 81-203 | N | 302 | 150/200 | 1 | 55 | 90 | 61 |
| 80-36 | N | 169 | 150/200 | 0 | 57 | 90 | 63 |
| 79-105 | N | 341 | 85/100 | 2 | 61 | 52 | 117* |
| 80-25 | E | 155 | 85/100 | 1 | 32 | 52 | 62 |
| 79-23 | E | 149 | 85/100 | 1 | 47 | 52 | 90 |
| 60:40 Recycling Ratio | | | | | | | |
| 80-230 | NW | 319 | 150/200 | 1 | 61 | 90 | 68 |
| 81-211 | NW | 308 | 150/200 | 1 | 71 | 90 | 79 |
| 80-211 | NW | 353 | 150/200 | 1 | 68 | 90 | 76 |
| 80-204 | NW | 284 | 150/200 | 1 | 80 | 90 | 87 |
| 81-212 | NW | 325 | 150/200 | 1 | 75 | 90 | 83 |
| 81-218 | NW | 322 | 150/200 | 1 | 67 | 90 | 74 |
| 50:50 Recycling Ratio | | | | | | | |
| 80-220 | NW | 341 | 150/200 | | 91 | 90 | 101 |
| 80-222 | NW | 312 | 150/200 | 1 | 49 | 90 | 54 |
| 80-218 | NW | 190 | 150/200 | 0 | 48 | 90 | 53 |
| 80-28 | E | 124 | 85/100 | 0 | 46 | 52 | 88 |

Note:

1) Average of percentage of desired penetration of recycled mixes using one grade softer A.C. is:

for 70:30 recycling ratio = 63%

for 60:40 recycling ratio = 78%

2) * = Using two grad softer A.C.

## RECOVERED RECYCLING ASPHALT A.C. (PEN.)

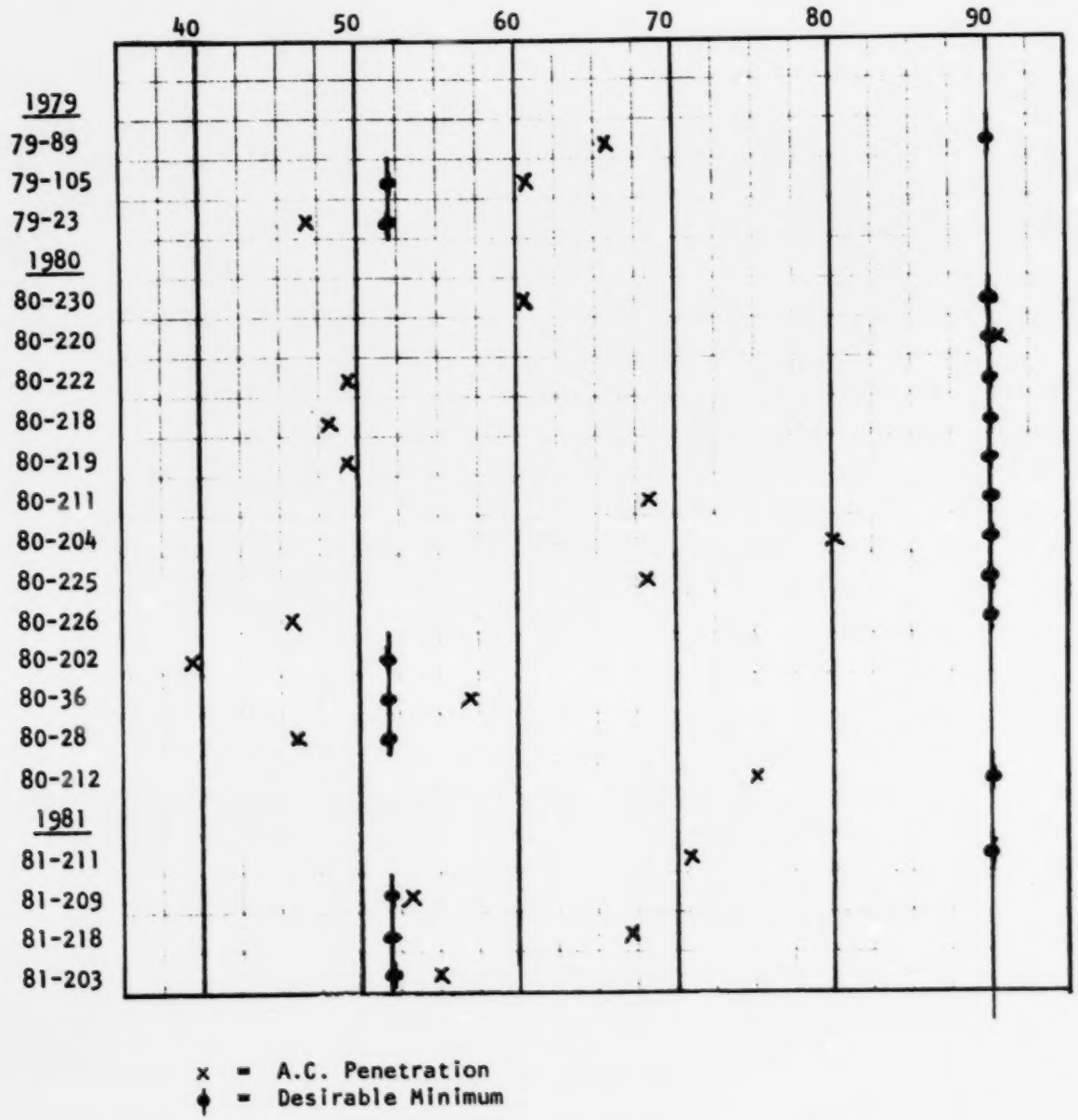



FIG. 6

Table 7: Recycling Asphalt Cement Penetration

| Contract | Recycle Ratio (x:y) | RAP A.C. Pen. (Po) | New A.C. Pen. (Pn) | Recycled Hot Mix A.C. Pen. (Pr) | Predicted Pen. (Pp) | % of Pred. (Pr/Pp) |
|---|---|---|---|---|---|---|
| 1980 | | | | | | |
| 80-220 | 50:50 | 23 | 341 | 91 | 69 | 132 |
| 80-222 | 50:50 | 16 | 312 | 49 | 55 | 89 |
| 81-211 | 60:40 | 39 | 308 | 71 | 73 | 97 |
| 80-218 | 50:50 | 32 | 190 | 48 | 60 | 80 |
| 80-219 | 70:30 | 28 | 291 | 49 | 48 | 102 |
| 80-211 | 60:40 | 36 | 353 | 68 | 73 | 93 |
| 79-89 | 70:30 | 34 | 290 | 66 | 56 | 118 |
| 80-204 | 60:40 | 63 | 284 | 80 | 94 | 85 |
| 1981 | | | | | | |
| 80-225 | 70:30 | 46 | 281 | 68 | 68 | 100 |
| 80-226 | 70:30 | 36 | 324 | 46 | 60 | 77 |
| 81-209 | 70:30 | 41 | 286 | 53 | 63 | 84 |
| 81-218 | 60:40 | 39 | 332 | 67 | 75 | 89 |
| 80-202 | 70:30 | 24 | 347 | 39 | 48 | 81 |
| 81-203 | 70:30 | 36 | 302 | 55 | 58 | 95 |
| 80-36 | 70:30 | 34 | 169 | 57 | 47 | 121 |
| 79-105 | 70:30 | 33 | 341 | 61 | 57 | 107 |
| 80-28 | 50:50 | 30 | 124 | 46 | 47 | 98 |
| 79-23 | 70:30 | 23 | 149 | 47 | 35 | 134 |

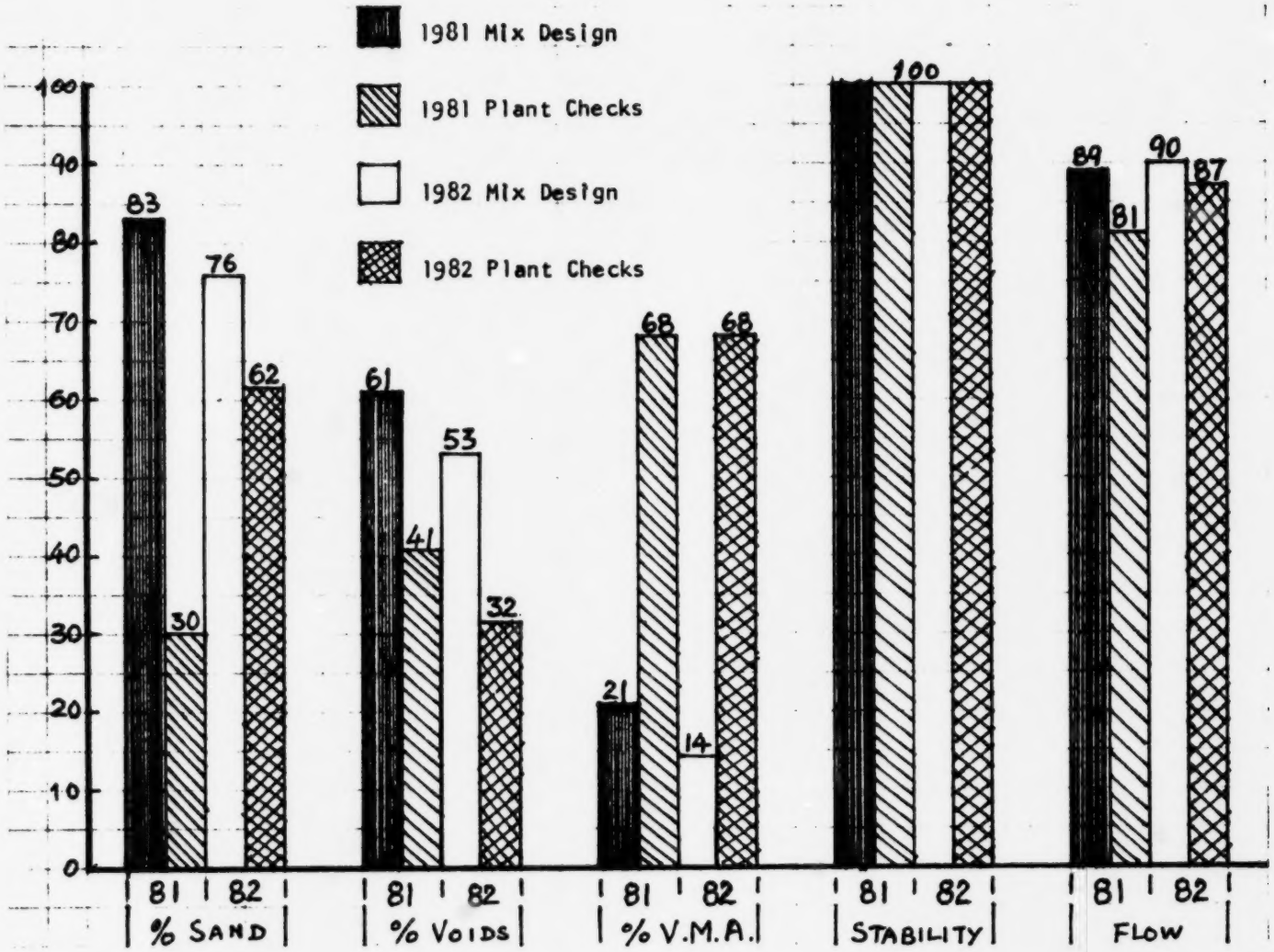



FIG. 7: PERCENTAGE OF MIXES MEETING DIFFERENT PROPERTY REQUIREMENTS

# APPENDIX 1

## GENERAL INFORMATION OF RECYCLING CONTRACTS

REGION: NORTH-WESTERN

| CONTRACT | HWY. | LOCATION | A.A.D.T. | QUANTITY | CONT. DESIGN RATIO | MIX DESIGN RATIO | VIRGIN AGG. SPECIFIED | VIRGIN AGG. ACTUAL |
|---|---|---|---|---|---|---|---|---|
| 80-220 | 618 | Red Lake | 350 | 12,500 | 50:50 | 50:50 | 16 mm A | St.Scr.Sa. |
| 80-232 | 17 | Dryden | 2,400 | 47,600 | 70:30 | 70:30 | St.Sa. | St. Sa. Bl. Sa. |
| 80-231 | 664 | Hudson | 600 | 13,500 | 55:45 | 40:60 | 16 mm A | 16 mm A. Bl. Sa. |
| 80-230 | 11 | Fort Frances | 2,500 | 102,100 | 70:30 | 70:30 B 60:40 S | St. Sa. | St.Bl.Sa. |
| 80-222 | 11 | Atikokan | 850 | 23,000 | 70:30 | 50:50 | 16 mm A | St.Bl.Sa. |
| 80-224 | 11 | Kashabowie | 1,200 | 14,500 | 70:30 | 60:40 | 16 mm A | 16 mm A. Bl.Sa. |
| 81-211 | 17 | Raith | 2,550 | 42,500 | 70:30 | 70:30 B 60:40 S | St.Sa. | St.Bl.Sa. |
| 80-218 | 11&17 | Thunder Bay | | 14,000 | 50:50 | 50:50 | 16 mm A | St. Sa. Bl. Sa. |
| 80-219 | 17 | Rossport | 1,600 | 45,000 | 70:30 | 70:30 | St. Sa. | St. Sa. Bl. Sa. |
| 80-211 | 17 | Jackfish | 1,800 | 68,500 | 70:30 | 70:30 B 60:40 S | St. Sa. | St. Sa. Bl. Sa. |
| 79-89 | 17 | Marathon | 2,000 | 63,000 | 70:30 | 70:30 | 16 mm A | St. Sa. Bl. Sa. |
| 80-204 | 17&614 | Rous Lake | 1,300 | 33,000 | 70:30 | 60:40 | St.& Sa. | St.Bl.Sa. |
| 80-229 | 17 | Wawa | 1,500 | 48,000 | 70:30 | 60:40 | 16 mm A | 16 mm A Bl. Sa. |
| 81-205 | 105 | Ear Falls | 675 | 48,800 | 70:30 | 70:30 | St.& Sa. | St. Sa. Bl. Sa. |
| 81-224 | 11 | Pickerel Riv. | 1,200 | 20,055 | 70:30 | 60:40 | 16 mm A | St. Sa. Bl. Sa. |
| 82-202 | 102 | Sistonen Corn. | 8,000 | 39,200 | 40:60 | 50:50 | 16 mm A | St. Sa. Bl. Sa. |
| 82-201 | 11&584 | Geraldton | 800 | 48,800 | 70:30 | M 70:30 C 60:40 | St. Sa. | St. Sa. Bl. Sa. |
| 81-220 | 556&552 | Heyden | 1,200 | 15,130 | 50:50 | 50:50 | 16 mm A | 16 mm A Bl. Sa. |
| 82-218 | 101&129 | Chapleau | 840 | 43,600 | 65:35 | | St. Sa. | |

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REGION: NORTHERN

| CONTRACT | HWY. | LOCATION | A.A.D.T. | QUANTITY | CONT. DESIGN RATIO | MIX DESIGN RATIO | VIRGIN AGG. SPECIFIED | VIRGIN AGG. ACTUAL |
|---|---|---|---|---|---|---|---|---|
| 80-214 | 11 | Hearst | 800 | 53,000 | 70:30 | 70:30 | 16 mm A | St.Bl.Sa. |
| 81-212 | 11 | Smooth Rock Falls | 1,650 | 52,300 | 70:30 | 60:40 | 16 mm A | 16 mm A |
| 80-225 | 11 | Cochrane | 2,000 | 53,800 | 70:30 | 70:30 | 16 mm A | 16 mm A |
| 80-226 | 66 | Kirkland Lake | 1,200 | 38,500 | 70:30 | 70:30 | 16 mm A | 16 mm A |
| 81-209 | 11 | South Y | 1,250 | 27,600 | 70:30 | 70:30 | 16 mm A | 16 mm A |
| 81-218 | 11 | New Liskeard | 3,500 | 34,900 | 70:30 | 60:40 | 16 mm A | 16 mm A |
| 80-215 | 69 | Sudbury | 4,900 | 49,500 | 70:30 | 70:30 | 16 mm A | 16 mm A |
| 80-202 | 17 | Warren | 4,000 | 22,000 | 70:30 | 70:30 | 16 mm A | 16 mm A |
| 81-203 | 17 | Verner | 3,450 | 34,000 | 70:30 | 70:30 | 16 mm A | 16 mm A |
| 80-36 | 17 | Deep River | 4,850 | 37,000 | 70:30 | 70:30 | 16 mm A | 16 mm A |
| 79-105 | 69 | Parry Sound | 5,500 | 81,400 | 70:30 | 70:30 | 16 mm A | 16 mm A |
| 80-51 | 60 | Algonquin W. | 1,250 | 12,500 | 70:30 | 70:30 | 16 mm A | 16 mm A |
| 81-221 | 11 | Opasatika | 1,700 | 54,300 | 70:30 | 70:30 | St. Sa. | St. Sa. |
| 81-200 | 17 | Massey | 4,200 | 111,700 | 70:30 | B70:30<br>S70:30 | 16 mm A | 16 mm A<br>St. Sa. |
| 82-209 | 17 | Mattawa | 5,400 | 25,500 | 70:30 | 70:30 | 16 mm A | 16 mm A |
| 81-22 | 11 | Huntsville | 5,900 | 29,200 | 70:30 | 60:40 | St. Sa. | St. Sa. |
| 81-13 | 121 | Haliburton | 4,500 | 37,600 | 70:30 | 70:30 | 16 mm A | 16 mm A |
| 82-53 | 141 | Rosseau | 750 | 31,800 | 40:60 | 40:60 | 16 mm A | 16 mm A |

Compiled by R.C. Evers

REGION: EASTERN

| CONTRACT | HWY. | LOCATION | A.A.D.T. | QUANTITY | CONT. DESIGN RATIO | MIX DESIGN RATIO | VIRGIN AGG. | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | SPECIFIED | ACTUAL |
| 80-28 | 15&29 | Smiths Falls | 3,200 | 24,500 | 50:50 | 50:50 | 16 mm A | St.Bl.Sa. |
| 80-25 | 7 | Kaladar | 3,100 | 45,700 | 70:30 | 70:30 | St. Sa. | St. Sa. |
| 79-23 | 41 | Napanee | 2,850 | 24,500 | 70:30 | 70:30 | 16 mm A | St.Bl.Sa. |
| 81-74 | 17&60 | Renfrew | 1,500 | 18,800 | 50:50 | 50:50 | St.Bl.Sa | St.Bl.Sa. |
| 81-16 | 14 | Crofton | 6,000 | 12,500 | 40:60 | 40:60 | St.Sa. | St. Sa. |
| 82-60 | 60&62 | Barrys Bay | 1,250 | 41,300 | 70:30 | | St.Sa. | |

COMPILED BY R.C.EVERS

REGION: CENTRAL

| CONTRACT | HWY. | LOCATION | A.A.D.T. | QUANTITY | CONT. DESIGN RATIO | MIX DESIGN RATIO | VIRGIN AGG. SPECIFIED | VIRGIN AGG. ACTUAL |
|---|---|---|---|---|---|---|---|---|
| 82-19 | 649 | Bobcaygeon | 1,000 | 16,700 | 30:70 | 30:70 | St. Sa. | St. Sa.<br>Bl. Sa. |
| 82-20 | 7&45 | Norwood | 4,900 | 32,000 | 50:50 | 50:50 | St. Sa. | St. Sa.<br>Bl. Sa. |
| 81-100 | 12 | Brooklin | 6,000 | 18,300 | 70:30 | 70:30 | St. Sa. | St. Sa. |
| 81-71 | 97 | Freelton | 1,100 | 8,300 | 50:50 | 50:50 | St. Sa. | St. Sa. |
| 81-88 | 5 | Clappison's Corners | 7,000 | 12,500 | 50:50 | 50:50 | St. Sa. | St. Sa. |
| 82-59 | 24&5 | Brantford | 2,500 | 19,100 | 50:50 | 50:50 | St. Sa. | St. Sa. |
| 81-86 | Q.E.W. | Fort Erie | 11,000 | S33,900 | 24:76 | 25:75 | St. Scr. | St. Scr. |
| | | | | B46,300 | 45:55 | 47:53 | St. Sa. | St. Scr.<br>Bl. Sa. |
| 82-83 | 20 | Bismark | 4,000 | S 8,300 | 30:70 | | St. Sa. | |
| | | | | B 1,500 | 70:30 | | St. Sa. | |

REGION: South Western

| CONTRACT | HWY. | LOCATION | A.A.D.T. | QUANTITY | CONT. DESIGN RATIO | MIX DESIGN RATIO | VIRGIN AGG. SPECIFIED | VIRGIN AGG. ACTUAL |
|---|---|---|---|---|---|---|---|---|
| 82-38 | 3 | Leamington | 1,150 | 24,200 | 50:50 | 50:50 | St. Sa. | St. Sa. |
| 82-04 | 2,21,79 | Thamesville | 1,900 | 36,100 | 70:30 | 70:30 | St. Sa. | St. Sa. |
| 82-43 | 3&73 | Aylmer | 7,000 | 15,100 | 50:50 | 40:60 | St. Sa. | St. Sa. |
| 82-69 | 19&86 | Milverton | 2,100 | 13,800 | 50:50 | 50:50 | St. Sa. | St. Sa. |
| 81-10 | 86 | Dorking | 3,700 | 25,000 | 70:30 | B70:30<br>S60:40 | 16 mm A | 16 mm A<br>St.Bl.Sa. |
| 82-06 | 93 | Crown Hill | 3,100 | 15,000 | 50:50 | 40:60 | St. Sa. | St. Sa. |

Compiled by R.C. Evers

# APPENDIX 2

## MIX DESIGN INFORMATION

**NORTHWESTERN**

| | | | | MIX DESIGN | | | | DESIGN MIX VALUES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONT. | QUANT. | LIFT | RAP | C.A. | $F.A._1$ | $F.A._2$ | A.C. | A.C. | SA. | VOIDS | FLOW | STAB. | V.M.A. (Specs.) |
| 80-220 | 12500 | S | 50 | 26.8 | SA 18.6 | SC 4.6 | 2.9 | 5.2 | 55 | 3.5 | 10.2 | 3000 | 14.4 (15.0) |
| | | S | 50 | 21.0 | SA 23.2 | SC 5.8 | 3.1 | 5.4 | 60 | 3.5 | 8.2 | 2630 | 15.6 (15.5) |
| 80-232 | 47600 | S | 70 | 16 | SA 7 | BL 7 | 1.6 | 5.4 | 60 | 3.0 | 10.2 | 2620 | 14.5 (15.5) |
| 80-231 | 71500 | S | 40 | 45A | BL 15 | | 3.8 | 5.3 | 60 | 3.3 | 8.8 | 2000 | 14.7 (15.5) |
| 80-230 | 102100 | B | 70 | 8 | BL 22 | | 2.3 | 5.0 | 64 | 3.4 | 11.7 | 3250 | 14.3 (16.0) |
| | | B | 70 | 18 | BL 12 | | 1.8 | 5.0 | 64 | 2.3 | 14.6 | 3740 | 13.7 (16.0) |
| | | S | 60 | 18 | BL 22 | | 2.0 | 5.1 | 60 | 3.2 | 11.2 | 3720 | 14.2 (15.5) |
| 80-222 | 23000 | S | 50 | 20 | BL 30 | | 3.0 | 5.2 | 60 | | | | |
| 80-224 | 14500 | S | 60 | 20A | BL 20 | | 2.5 | 5.1 | 60 | | | | |
| 81-211 | 42500 | B | 70[c] | 9 | BL 21 | | 2.5 | 5.2 | 65 | 2.5 | 10.6 | 3020 | 14.8 (16.0) |
| | | S | 60[c] | 20 | BL 20 | | 3.0 | 5.3 | 60 | 3.1 | 10.5 | 2740 | 14.5 (15.0) |
| | | S | 60[m] | 21 | BL 19 | | 2.0 | 5.3 | 59 | 3.2 | 11.5 | 3200 | 14.5 (15.0) |
| 80-218 | 14000 | B | 40 | 26 | SA 9 | BL 25 | 3.0 | 5.0 | 60 | 3.2 | 9.1 | 2775 | 14.4 |
| | | B | 45 | 24 | BL 31 | | 2.8 | 5.0 | 60 | 3.7 | 8.6 | 2150 | 14.7 (15.5) |
| | | B | 50 | 17 | BL 33 | | 3.0 | 5.5 | 65 | 4.0 | 9.8 | 2600 | 15.1 (16.0) |
| 80-219 | 45000 | S | 70[m] | 5 | BL 21 | SC 4 | 1.8 | 5.3 | 60 | 3.0 | 10.8 | 2650 | 14.9 (15.5) |
| | | S | 70[c] | 6 | SA 6 | BL 18 | 2.5 | 5.3 | 60 | 3.5 | 16.0 | 2875 | 14.5 (15.5) |
| 80-211 | 68500 | B | 70 | 11 | SA 9 | BL 10 | 2.2 | 5.2 | 60 | 2.6 | 12.3 | 2870 | 13.5 (15.5) |
| | | S | 60 | 14 | SA 16 | BL 10 | 2.7 | 5.2 | 60 | 3.2 | 12.0 | 2950 | 14.4 (15.5) |
| 79-89 | 63000 | S | 70 | 14 | SA 6 | BL 10 | 2.3 | 5.1 | 60 | 3.7 | 10.3 | 2820 | 14.5 (15.5) |
| 80-204 | 33000 | S | 60 | 20 | BL 20 | | 2.0 | 5.1 | 60 | 3.3 | 9.0 | 2710 | 14.6 (15.5) |
| 80-224 | 48000 | S | 60 | 24 | BL 16 | | 2.6 | 5.1 | 60 | | | | |

NORTH WESTERN

| | | MIX DESIGN | | | | | DESIGN MIX VALUES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONT. | LIFT | MIX | C.A. | $F.A._1$ | $F.A._2$ | A.C. | A.C. | SA. | VOIDS | FLOW | STAB. | V.M.A. (Specs.) |
| 81-205 | S | M70 | 14 | 8 Sa. | 8 Bl. | 1.8 | 5.4 | 60 | 3.3 | 12.7 | 10300 | 15.3 (15.0) |
| | S | C70 | 8.5 | 10.7 Sa. | 10.8 Bl. | 2.1 | 5.3 | 60 | 3.5 | 9.5 | 11200 | 15.4 (15.0) |
| 81-224 | S | C60 | 13 | 13.5 Sa. | 13.5 Bl. | 2.7 | 5.2 | 60 | 2.8 | 9.2 | 10000 | 14.6 (15.0) |
| 82-202 | S | C50 | 29 | 7 Sa. | 14 Bl. | 2.6 | 5.1 | 60 | 2.6 | 11.3 | 13300 | 13.5 (15.0) |
| 82-201 | S | M70 | 14 | 10 Sa. | 6 Bl. | 1.6 | 5.2 | 60 | 3.0 | 12.8 | 10700 | 14.7 (15.0) |
| | | C60 | 20 | 12 Sa. | 8 Bl. | 2.3 | 5.1 | 60 | 2.6 | 12.7 | 12700 | 14.7 (15.0) |
| 81-220 | S | C50 | 35A | 15 Bl. | | 3.1 | 5.4 | 62 | 3.1 | 8.3 | 10000 | 14.7 (15.0) |

REGION: NORTHERN

| | | MIX DESIGN | | | | | DESIGN MIX VALUES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONT. | LIFT | RAP | C.A. | F.A.$_1$ | F.A.$_2$ | A.C. | A.C. | SA. | VOIDS | FLOW | STAB. | V.M.A. (Specs.) |
| 80-214 | S | 70 | 12 | 18 Bl. | | 2.0 | 5.0 | 65 | 3.0 | 12.1 | 13061 | |
| 81-212 | S | 60 | 40A | | | 1.8 | 4.6 | 58 | 3.1 | 11.1 | 11962 | 12.9 (15.5) |
| 80-225 | B | 70 | 30A | | | 2.1 | 5.0 | 57 | 2.7 | 13.5 | 10324 | 14.9 (15,0) |
| | S | 70 | 30A | | | 1.8 | 4.7 | 57 | 3.4 | 12.4 | 10756 | 14.9 (15.0) |
| 80-226 | B | 70 | 30A | | | 2.2 | 5.3 | 57 | 3.2 | 13.1 | 12238 | 14.4 (14.4) |
| | S | 70 | 30A | | | 2.0 | 5.1 | 57 | 3.6 | 12.4 | 11993 | 14.4 (14.5) |
| 81-209 | S | 70 | 30A | | | 1.9 | 4.7 | 57 | 3.1 | 10.8 | 10591 | 12.9 (15.0) |
| 81-218 | S | 60 | 40A | | | 2.5 | 4.9 | 58 | | | | |
| 80-215 | B | 70 | 30A | | | 2.0 | 4.8 | 62 | 3.2 | 11.8 | 10444 | |
| 80-202 | B | 70 | 30A | | | 1.9 | 4.6 | 58 | 2.9 | 12.2 | 12638 | |
| 81-203 | B | 70 | 30A | | | 2.3 | 4.7 | 64 | 3.2 | 12.0 | 10124 | 13.6 (16.0) |
| 80-36 | B | 70 | 30A | | | 2.8 | 5.0 | 57 | 2.8 | 13.3 | 12749 | |
| 79-105 | B | 70 | 30A | | | 2.0 | 5.2 | 57 | 2.1 | 13.2 | 11570 | |
| 80-51 | S | 70 | 30A | | | 2.1 | 5.0 | 56 | | | | |
| 81-221 | S | 70 | 17 | 13 | | 2.3 | 5.2 | 60 | 3.5 | 12.4 | 11091 | 13.5 (15.0) |
| 81-200 | B | 70 | 30A | | | 1.5 | 4.9 | 58 | 1.9 | 14.7 | 11473 | 13.4 (15.0) |
| | S | 70 | 20 | 10 | | 1.9 | 4.8 | 64 | 3.3 | 10.6 | 11375 | 14.5 (15.5) |
| 82-209 | S | 70 | 30A | | | 2.3 | 4.8 | 61 | 3.5 | 13.7 | 20497 | |
| 82-53 | S | 40 | 60A | | | 3.3 | 4.7 | 57 | 3.5 | 9.7 | 11250 | 13.3 (14,5) |
| 81-22 | B | 60 | 30 | 10 | | 1.4 | 5.0 | 60 | 3.3 | 12.7 | 14500 | 13.6 (15.0) |
| 81-13 | B | 70 | 30A | | | 2.3 | 5.3 | 58 | 3.4 | 13.2 | 14500 | 14.7 (15.0) |
| 82-42 | B | 70 | 22 | 8 | | 2,3 | 5.3 | 60 | 3.4 | 11.2 | 12225 | 14.3 (15.0) |
| | S | 65 | 26 | 9 | | 2.1 | 4.9 | 57 | 3.5 | 11.2 | 13625 | 13.7 (14.5) |

REGION: EASTERN

| | | MIX DESIGN | | | | | DESIGN MIX VALUES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONT. | MIX | RAP | C.m. | F.A.1 | F.A.2 | A.C. | A.C. | SA. | VOIDS | FLOW | STAB. | V.M.A. (Specs.) |
| 80-28 | S | 50S | 33 | 17 Bl. | | 2.0 | 4.7 | 57 | 3.6 | 13.0 | 3150 | 12.7 (15.0) |
| | S | 50C | 33 | 17 Bl. | | 2.1 | 4.7 | 52 | 3.0 | 13.3 | 3475 | 12.7 (15.0) |
| 80-25 | B | 70 | 15 | 15 | | 1.8 | 5.0 | 57 | 2.9 | 10.6 | 2410 | 14.0 (15.0) |
| 79-23 | S | 70 | 24 | 6 Bl. | | 1.5 | 5.0 | 59 | 2.4 | 16.7 | 2700 | |
| 81-74 | S | 50 | 30 | 20 | | 2.7 | 5.1 | 54 | 2.3 | 11.5 | 13100 | 13.3 (14.5) |
| 81-16 | S | 40 | 30 | 30 Bl. | | 3.3 | 5.3 | 58 | 3.5 | 8.7 | 10500 | 14.4 (15.0) |
| 82-60 | No design yet. | | | | | | | | | | | |

SOUTHWESTERN

| | | MIX DESIGN | | | | | DESIGN MIX VALUES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONT. | LIFT | RAP | C.A. | F.A.$_1$ | F.A.$_2$ | A.C. | A.C. | SA. | VOIDS | FLOW | STAE. | V.M.A. (Specs.) |
| 82-36 | S | 50 | 20 | 30 | | 2.8 | 5.5 | 65 | 3.8 | 11.7 | 12988 | 16.6 (16.0) |
| 82-04 | S | 70 | 10 | 20 Bl. | | 1.7 | 5.3 | 64 | 3.0 | 13.8 | 16280 | 13.9 (15.5) |
| 82-43 | B | 40 | 30 | 30 | | 3.2 | 5.5 | 58 | 3.1 | 12.3 | 12721 | 15.6 (15.0) |
| 82-69 | S | 50 | 20 | 30 | | 2.6 | 5.5 | 62 | 3.2 | 13.2 | 14456 | 14.4 (15.0) |
| 81-10 | B | 70 | 30A | | | 1.4 | 5.3 | 66 | 2.2 | 18.0 | 9786 | 13.8 (15.5) |
| | S | 60 | 20 | 20 Bl | | 1.8 | 5.6 | 63 | 4.2 | 13.0 | 11743 | 16.6 (15.0) |
| 82-06 | S | 40 | 20 | 40 | | 3.2 | 5.3 | 63 | 3.0 | 10.2 | 7784 | 14.7 (15.5) |

SECTION: CENTRAL

| | | MIX DESIGN | | | | | DESIGN MIX VALUES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONT. | LIFT | RAP | C.A. | $F.A._1$ | $F.A._2$ | A.C. | A.C. | SA. | VOIDS | FLOW | STAB. | V.M.A. (Specs.) |
| 82-20 | B | 40 | 27 | 26 | 7 Bl. | 3.3 | 5.2 | 55 | 1.3 | 11.1 | 14500 | 12.6 (14.5) |
| 82-19 | S | 30 | 31 | 19 | 19 Bl. | 4.5 | 5.3 | 55 | 2.8 | 10.2 | 9800 | 13.8 (14.5) |
| 81-100 | B | 70 | 14 | 16 | | 2.0 | 5.0 | 55 | 1.3 | 21.3 | 16300 | 12.5 (14.5) |
| 81-71 | B | 50 | 19 | 31 | | 2.6 | 5.1 | 60 | 2.2 | 13.2 | 14400 | 13.5 (15.0) |
| 81-88 | B | 40 | 27 | 33 | | 3.0 | 5.3 | 55 | 1.5 | 15.7 | 16500 | 12.7 (14.0) |
| 82-59 | B | 50 | 30 | 20 | | 2.7 | 5.1 | 55 | 1.7 | 14.8 | 14600 | 13.0 (14.0) |
| 81-86 | B | 47 | 26 | 24 | | 3.0 | 5.0 | 50 | 1.2 | 184 | 16650 | |
| | S | 25 | 25 | 25 Sc. | | 4.4 | 5.9 | 55 | 2.2 | 27.4 | 12500 | |
| 82-83 | | No designs yet. | | | | | | | | | | |

# APPENDIX 3

## PLANT CHECKS RESULTS

**NORTHWESTERN REGION**

SUMMARY OF PLANT CHECKS

| | | | A.C. | SA. | VOIDS | FLOW | STAB. | V.M.A. | %PASS. 200 IN SAND | B.S.G. | M.S.G. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 80-220 | Reg. Lab. | x | 5.3 | 61.1 | 3.4 | 10.9 | 3249 | 14.9 | 7.6 | 2.394 | 2.477 |
| 50:50 | n=10 | σ | 0.20 | 2.18 | 0.89 | 0.88 | 400.3 | 0.49 | 0.24 | 0.016 | 0.010 |
| | Mob. Lab. | x | 5.0 | 55.0 | 2.7 | 10.2 | 3458 | 14.9 | 8.2 | 2.428 | 2.495 |
| | n=11 | σ | 0.24 | 2.70 | 0.45 | 0.90 | 308.6 | 0.51 | 0.64 | 0.008 | 0.003 |
| 80-232 | Reg. Lab. | x | 5.14 | 62.2 | 3.08 | 11.3 | 3899 | 13.9 | 6.8 | 2.397 | 2.474 |
| 70:30 | n=23 | σ | 0.27 | 3.71 | 0.61 | 1.04 | 563.9 | 0.80 | 1.20 | 0.021 | 0.015 |
| | Mob. Lab. | x | 5.45 | 62.5 | 2.74 | 9.45 | 3319.7 | 14.16 | 5.94 | 2.396 | 2.464 |
| | n=14 | σ | 0.29 | 2.66 | 0.82 | 1.23 | 363.9 | 0.31 | 2.14 | 0.013 | 0.011 |
| 80-231 | Reg. Lab. | x | 5.06 | 64.4 | 3.72 | 7.77 | 1941 | 14.9 | 5.99 | 2.393 | 2.487 |
| 40:60 | n=10 | σ | 0.10 | 2.68 | 0.93 | 0.61 | 325.9 | 0.83 | 0.81 | 0.022 | 0.007 |
| 80-230 | Reg. Lab. | x | 5.0 | 64.1 | 2.9 | 9.7 | 3844 | 13.2 | 7.5 | 2.464 | 2.536 |
| 70:30 Binder | n=18 | σ | 0.5 | 4.3 | 0.7 | 0.7 | 482 | 0.7 | 1.8 | 0.016 | 0.014 |
| | Reg. Lab. | x | 5.2 | 62.7 | 2.4 | 13.2 | 3516 | 13.5 | 9.2 | 2.425 | 2.485 |
| 60:40 Surface | n=10 | σ | 0.2 | 3.5 | 0.4 | 1.1 | 226 | 0.4 | 0.8 | 0.013 | 0.008 |
| 80-222 | Reg. Lab. | x | 5.25 | 62.6 | 1.69 | 13.28 | 3760 | 12.7 | 8.31 | 2.441 | 2.495 |
| 50:50 | n=17 | σ | 0.14 | 1.71 | 0.48 | 1.04 | 527.9 | 0.45 | 0.76 | 0.010 | 0.006 |
| 80-224 | Mob. Lab. | x | 5.39 | 64.5 | 2.64 | 9.92 | 3445 | 14.4 | 5.08 | 2.421 | 2.487 |
| 60:40 | n=9 | σ | 0.16 | 5.95 | 0.51 | 0.76 | 247.38 | 0.41 | 0.98 | 0.011 | 0.005 |
| 81-211 | Reg. Lab. | x | 5.38 | 64.0 | 2.3 | 12.7 | 3780 | 13.7 | 9.2 | 2.471 | 2.531 |
| 70:30 Binder | n=21 | σ | 0.49 | 3.1 | 1.1 | 2.2 | 7.92 | 0.8 | 1.7 | 0.018 | 0.021 |
| | Mob. Lab. | x | 5.41 | 63.9 | 2.6 | 12.1 | 3173 | 14.3 | 7.8 | 2.463 | 2.529 |
| 70:30 Binder | n=16 | σ | 0.27 | 3.3 | 0.9 | 2.0 | 403 | 0.6 | 1.0 | 0.015 | 0.009 |
| | Reg. Lab. | | | | | | | | | | |
| 60:40 Surface | n=39 | x | 5.2 | 60.1 | 2.7 | 11.5 | 3931 | 14.1 | 8.1 | 2.461 | 2.530 |
| | | σ | 0.24 | 3.7 | 0.9 | 1.1 | 390 | 0.8 | 0.7 | 0.020 | 0.012 |
| | Mob. Lab. | x | 5.44 | 61.2 | 3.0 | 9.3 | 3130 | 14.4 | 5.5 | 2.452 | 2.528 |
| 60:40 Surface | n=12 | σ | 0.15 | 2.6 | 0.7 | 1.8 | 555 | 0.9 | 1.4 | 0.016 | 0.008 |
| 80-219 | Reg. Lab. | x | 5.4 | 62.0 | 3.2 | 10.6 | 3646 | 14.6 | 6.0 | 2.390 | 2.375 |
| | n=23 | σ | 0.30 | 3.4 | 0.8 | 2.1 | 530 | 0.8 | 1.6 | 0.027 | 0.016 |

NORTHWESTERN REGION

SUMMARY OF PLANT CHECKS

| | | | A.C. | SA. | VOIDS | FLOW | STAB. | V.M.A. | %PASS. 200 IN SAND | B.S.G. | M.S.G. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 80-218 | Reg. Lab. | x | 5.3 | 69.4 | 4.6 | 8.4 | 2906 | 17.2 | 4.93 | 2.437 | 2.554 |
| 50:50 | n=9 | σ | 0.17 | 2.49 | 1.01 | 0.65 | 335 | 0.90 | 1.05 | 0.021 | 0.007 |
| | Mob. Lab. | x | 5.1 | 62.0 | 2.6 | 8.8 | 3047 | 14.8 | 5.49 | 2.474 | 2.566 |
| | n=25 | σ | 0.17 | 3.00 | 0.72 | 0.96 | 376 | 0.78 | 1.22 | 0.019 | 0.008 |
| 80-211 | Reg. Lab. | x | 5.11 | 60.3 | 3.65 | 9.74 | 2649 | 14.7 | 7.07 | 2.404 | 2.506 |
| 60:40 | n=7 | σ | 0.38 | 5.15 | 0.15 | 0.48 | 235.8 | 0.81 | 0.52 | 0.014 | 0.015 |
| 79-89 | Reg. Lab. | x | 5.1 | 58.7 | 2.5 | 12.9 | 3564 | 14.5 | 8.04 | 2.420 | 2.498 |
| 70:30 | n=25 | σ | 0.18 | 3.94 | 0.83 | 1.12 | 792 | 0.69 | 0.33 | 0.017 | 0.009 |
| | Mob. Lab. | x | 5.1 | 60.1 | 3.6 | 8.3 | 2853 | 15.8 | 5.81 | 2.407 | 2.476 |
| | n=46 | σ | 0.21 | 4.18 | 0.99 | 0.97 | 484 | 0.78 | 1.15 | 0.258 | 0.069 |
| 80-204 | Reg. Lab. | x | 4.9 | 61.9 | 4.2 | 9.1 | 2767 | 15.6 | 8.11 | 2.389 | 2.498 |
| 60:40 | n=7 | σ | 0.32 | 3.02 | 0.96 | 0.93 | 709 | 0.84 | 0.31 | 0.013 | 0.013 |
| | Mob. Lab. | x | 5.1 | 63.3 | 3.1 | 8.8 | 3077 | 15.4 | 5.77 | 2.402 | 2.492 |
| | n=28 | σ | 0.15 | 1.75 | 0.71 | 1.18 | 438 | 0.69 | 0.95 | 0.018 | 0.010 |
| 80-229 | Reg. Lab. | x | 5.2 | 60.6 | 3.2 | 11.0 | 2842.2 | 14.1 | 7.16 | 2.460 | 2.543 |
| 60:40 | n=24 | σ | 0.17 | 3.96 | 0.79 | 1.04 | 272 | 0.56 | 0.42 | 0.018 | 0.011 |
| 81-205 | Reg. Lab. | x | 5.2 | 59.7 | 2.8 | 12.8 | 17496 | 14.0 | 8.1 | 2.453 | |
| | n=17 | σ | 0.25 | 3.27 | 0.67 | 1.12 | 1996 | 0.47 | 0.67 | 0.013 | |
| | Mob. Lab | x | 5.3 | 58.1 | 1.8 | 14.6 | 17277 | 13.5 | 7.6 | 2.467 | 2.511 |
| | n=37 | σ | 0.20 | 2.99 | 0.45 | 1.55 | 1250 | 0.46 | 0.39 | 0.014 | 0.012 |
| 81-224 | Reg. Lab. | x | 5.3 | 62.7 | 3.9 | 11.4 | 16887 | 14.6 | 7.1 | 2.400 | 2.497 |
| 60:40 | n=10 | σ | 0.27 | 4.01 | 0.75 | 0.51 | | 0.50 | 0.60 | 0.014 | 0.010 |
| | Mob. Lab. | x | 5.3 | 63.1 | 2.1 | 10.8 | 13282 | 14.4 | 6.1 | 2.404 | 2.481 |
| | n=18 | σ | 0.23 | 3.15 | 0.72 | 0.80 | | 0.60 | 0.37 | 0.016 | 0.010 |
| 82-220 | Reg. Lab. | x | 5.5 | 67.2 | 4.0 | 9.2 | 11435 | 15.5 | 6.0 | 2.437 | 2.538 |
| | n=8 | σ | | | | | | | | | |
| | Mob. Lab. | x | 5.3 | 63.9 | 3.0 | 8.2 | 12528 | 14.3 | 5.5 | 2.465 | 2.540 |
| | n=6 | σ | | | | | | | | | |
| 80-229 | Reg. Lab. | x | 5.3 | 61.4 | 3.0 | 10.7 | 13328 | 14.1 | 7.5 | 2.457 | 2.533 |
| | n=21 | σ | 0.25 | 3.27 | 0.71 | 1.05 | 2074 | 0.60 | 0.33 | 0.020 | 0.01 |
| | Mob. Lab. | x | 5.2 | 60.6 | 3.1 | 11.1 | 12878 | 14.0 | 7.3 | 2.463 | 2.542 |
| | n=29 | σ | 0.19 | 3.66 | 0.77 | 0.99 | 1375 | 0.58 | 0.47 | 0.017 | 0.007 |

# SUMMARY OF PLANT CHECKS

NORTHERN REGION

| | | | A.C. | SA. | VOIDS | FLOW | STAB. | V.M.A. | %PASS. 200 IN SAND | B.S.G. | M.S.G. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 80-214 70:30 | Reg. Lab. n=24 | x | 4.9 | 64.0 | 4.0 | 10.5 | 2639 | 15.6 | 6.6 | 2.372 | 2.488 |
| | | σ | 0.44 | 1.97 | 1.72 | 1.09 | 404 | 0.84 | 0.77 | 0.027 | 0.020 |
| | Mob. Lab. n=5 | x | 4.9 | 61.2 | 3.9 | 12.7 | 3244 | 15.6 | 8.34 | 2.397 | 2.495 |
| | | σ | 0.45 | 2.46 | 0.90 | 0.73 | 222 | 0.45 | 0.39 | 0.014 | 0.015 |
| 81-212 | Reg. Lab. n=43 | x | 4.6 | 60.7 | 3.1 | 11.6 | 3332 | 14.15 | 7.7 | 2.451 | 2.529 |
| | | σ | 0.4 | 4.1 | 1.1 | 1.8 | 357 | 0.6 | 0.7 | 0.017 | 0.016 |
| 80-225 70:30 | Reg. Lab. n=3 | x | 5.1 | 61.1 | 5.4 | 14.6 | 2245 | 14.6 | 9.5 | 2.452 | 2.503 |
| | | σ | 0.32 | 1.75 | 5.57 | 2.10 | 815.2 | 0.58 | 0.20 | 0.006 | 0.005 |
| 70:30 | Mob. Lab. n=20 | x | 4.9 | 62.5 | 3.3 | 11.5 | 2775 | 15.7 | 5.1 | 2.425 | 2.508 |
| | | σ | 0.37 | 3.09 | 0.72 | 1.27 | 265.3 | 0.62 | 0.54 | 0.011 | 0.014 |
| 80-226 70:30 | Reg. Lab. n=5 | x | 4.9 | 62.0 | 4.8 | 11.6 | 3247 | 16.9 | 5.7 | 2.453 | 2.575 |
| | | σ | 0.18 | 2.80 | 0.35 | 1.01 | 124.5 | 0.53 | 0.32 | 0.012 | 0.007 |
| 81-209 70:30 | Reg. Lab. n=4 | x | 4.9 | 55.3 | 3.5 | 10.7 | 3047 | 15.5 | 6.2 | 2.449 | 2.538 |
| 81-218 60:40 | Reg. Lab. n=11 | x | 5.2 | 59.1 | 2.6 | 13.9 | 3157 | 15.5 | 8.4 | 2.491 | 2.556 |
| | | σ | 0.24 | 3.25 | 0.44 | 1.33 | 267 | 0.40 | 0.81 | 0.011 | 0.015 |
| 60:40 | Mob. Lab. n=17 | x | 5.0 | 59.6 | 3.3 | 12.4 | 2955 | 15.5 | 7.6 | 2.468 | 2.551 |
| | | σ | 0.12 | 2.80 | 0.60 | 0.86 | 345.1 | 0.51 | 0.37 | 0.012 | 0.010 |
| 80-215 70:30 | Reg. Lab. n=17 | x | 5.1 | 63.4 | 2.8 | 13.1 | 3336 | 15.4 | 7.68 | 2.475 | 2.545 |
| | | σ | 0.39 | 2.07 | 0.83 | 1.48 | 425 | 0.36 | 0.45 | 0.013 | 0.016 |
| | Mob. Lab. n=9 | x | 4.7 | 63.6 | 2.4 | 14.8 | 3849 | 14.1 | 7.21 | 2.480 | 2.540 |
| | | σ | 0.28 | 2.28 | 0.95 | 1.55 | 277 | 0.41 | 1.04 | 0.013 | 0.012 |
| 80-202 70:30 | Reg. Lab. n=10 | x | 4.7 | 66.3 | 3.5 | 13.6 | 3324 | 15.1 | 8.18 | 2.470 | 2.559 |
| | | σ | 0.31 | 2.83 | 0.85 | 0.82 | 294 | 0.20 | 0.24 | 0.012 | 0.012 |
| | Mob. Lab. n=5 | x | 5.1 | 66.0 | 2.4 | 15.1 | 3946 | 15.2 | 7.38 | 2.498 | 2.559 |
| | | σ | 0.17 | 0.99 | 0.16 | 1.27 | 344 | 0.35 | 0.99 | 0.006 | 0.009 |
| 81-203 70:30 | Reg. Lab. n=18 | x | 4.7 | 63.7 | 2.5 | 13.0 | 3626 | 14.2 | 7.3 | 2.497 | 2.561 |
| | | σ | 0.36 | 3.91 | 0.87 | 1.80 | 461.7 | 0.55 | 0.392 | 0.033 | 0.017 |
| 80-36 70:30 | Reg. Lab. n=14 | x | 5.0 | 56.4 | 2.8 | 13.7 | 3992 | 14.9 | 10.6 | 2.413 | 2.484 |
| | | σ | 0.37 | 4.96 | 0.54 | 1.01 | 379 | 0.69 | 0.52 | 0.007 | 0.013 |
| | Mob. Lab. n=5 | x | 5.1 | 56.2 | 3.4 | 12.3 | 3460 | 15.5 | 9.3 | 2.400 | 2.485 |
| | | σ | 0.24 | 5.50 | 0.53 | 0.61 | 355 | 0.86 | 0.37 | 0.013 | 0.003 |

## SUMMARY OF PLANT CHECKS

NORTHERN REGION

| | | | A.C. | SA. | VOIDS | FLOW | STAB. | V.M.A. | %PASS. 200 IN SAND | B.S.G. | M.S.G. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 79-105 | Reg. Lab. | x | 5.2 | 63.9 | 2.4 | 13.5 | 3316 | 15.3 | 9.5 | 2.475 | 2.535 |
| 70:30 | n=45 | σ | 0.21 | 2.24 | 0.39 | 1.86 | 322 | 0.55 | 0.88 | 0.01 | 0.01 |
| | Mob. Lab. | x | 5.7 | 61.7 | 1.9 | 13.4 | 3370 | 16.0 | 9.3 | 2.480 | 2.529 |
| | n=21 | σ | 0.45 | 1.74 | 0.51 | 1.61 | 335 | 0.84 | 1.78 | 0.01 | 0.02 |
| 80-51 | Reg. Lab. | x | 4.6 | 57.6 | 3.1 | 9.5 | 3873 | 14.4 | 9.1 | 2.452 | 2.530 |
| 70:30 | n=10 | σ | 0.29 | 3.45 | 0.77 | 0.87 | 240.7 | 0.60 | 0.50 | 0.007 | 0.015 |

NORTHERN REGION

## SUMMARY OF PLANT CHECKS

| | | | A.C. | SA. | VOIDS | FLOW | STAB. | V.M.A. | % PASS. 200 IN SAND | B.S.G. | M.S.G. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 81-221 | Reg.Lab. | x | 5.2 | 58.3 | 3.6 | 11.0 | 12867 | 16.2 | 8.4 | | |
| 70:30 | n = 18 | σ | 0.23 | 2.62 | 0.65 | 0.84 | 1751 | 0.77 | 0.51 | | |
| | Mob.Lab. | x | 5.1 | 59.4 | 3.0 | 11.6 | 14030 | 15.5 | 7.6 | | |
| | n = 30 | σ | 0.18 | 2.80 | 0.55 | 1.06 | 1195 | 0.55 | 0.54 | | |
| 81-200 | Reg.Lab. | x | 4.8 | 58.8 | 2.6 | 13.5 | 14469 | 14.4 | 9.6 | 2.496 | 2.562 |
| 70:30 | n = 22 | σ | 0.24 | 3.18 | 0.51 | 1.21 | 1066 | 0.40 | 0.43 | 0.01 | 0.02 |
| Binder | | | | | | | | | | | |
| | Mob.Lab. | x | 4.9 | 60.5 | 1.7 | 13.4 | 15530 | 14.0 | 9.0 | 2.499 | 2.536 |
| | n = 19 | σ | 0.29 | 3.33 | 0.41 | 1.17 | 1398 | 0.57 | 0.31 | 0.01 | 0.03 |
| 70:30 | Reg.Lab. | x | 4.7 | 58.9 | 3.6 | 11.1 | 13582 | 15.2 | 8.3 | 2.469 | 2.562 |
| Surface | n = 21 | σ | 0.23 | 2.53 | 0.60 | 0.99 | 1413 | 0.54 | 0.53 | 0.02 | 0.01 |
| 82-209 | Reg.Lab. | x | 5.3 | 61.2 | 4.0 | 13.4 | 16797 | 16.5 | 8.5 | | |
| 70:30 | n = 18 | σ | 0.28 | 4.84 | 0.74 | 0.82 | 1424 | 0.59 | 0.40 | | |
| | Mob.Lab. | x | 4.9 | 63.4 | 3.8 | 13.2 | 16966 | 15.6 | 7.8 | | |
| | n = 14 | σ | 0.24 | 3.13 | 0.66 | 0.66 | 1674 | 0.51 | 0.26 | | |
| 82-42 | Reg.Lab. | x | 5.5 | 63.7 | 3.3 | 11.9 | 14318 | 16.3 | 8.1 | | |
| 70:30 | n = 17 | σ | 0.44 | 3.74 | 0.94 | 1.04 | 2047 | 0.67 | 1.15 | | |
| Binder | | | | | | | | | | | |
| | Mob.Lab. | x | 5.1 | 61.9 | 3.2 | 13.3 | 17388 | 15.6 | 8.4 | | |
| | n = 12 | σ | 0.37 | 3.68 | 1.31 | 1.40 | 1985 | 1.10 | 1.07 | | |
| 65:35 | Reg.Lab. | x | 4.9 | 59.0 | 4.1 | 11.9 | 15411 | 16.0 | 8.2 | | |
| Surface | n = 25 | σ | 0.28 | 4.15 | 0.73 | 1.13 | 1550 | 0.61 | 1.03 | | |
| | Mob.Lab. | x | 4.7 | 59.1 | 3.8 | 12.0 | 17086 | 15.2 | 8.3 | | |
| | n = 11 | σ | 0.34 | 2.52 | 0.65 | 0.76 | 1832 | 0.37 | 0.86 | | |
| 82-53 | Reg.Lab. | x | 5.0 | 54.4 | 2.7 | 11.2 | 13977 | 15.0 | 8.7 | 2.470 | 2.537 |
| 40:60 | n = 14 | σ | 0.21 | 3.63 | - | 0.73 | 1106 | 0.44 | 0.53 | 0.01 | 0.01 |
| | Mob.Lab. | x | 5.2 | 55.8 | 1.8 | 9.4 | 14635 | 14.8 | 8.2 | 2.480 | 2.525 |
| | n = 5 | σ | 0.06 | 2.23 | 0.27 | 0.60 | 834 | 0.26 | 0.13 | 0.01 | 0.01 |
| 81-22 | Reg.Lab. | x | 5.0 | 57.9 | 3.3 | 11.1 | 14444 | 15.7 | 9.1 | 2.476 | 2.561 |
| 60:40 | n = 23 | σ | 0.27 | 3.46 | 0.77 | 1.28 | 1486 | 0.55 | 0.75 | 0.02 | 0.01 |
| | Mob.Lab. | x | 5.0 | 58.7 | 2.2 | 10.8 | 16055 | 14.8 | 8.1 | 2.493 | 2.549 |
| | n = 14 | σ | 0.23 | 4.87 | 0.77 | 2.32 | 1816 | 0.83 | 0.71 | 0.02 | 0.01 |
| 81-13 | Reg.Lab. | x | 5.5 | 59.9 | 2.6 | 12.6 | 14725 | 15.9 | 9.9 | 2.454 | 2.519 |
| | n = 12 | σ | 0.16 | 2.40 | 0.26 | 0.55 | 874 | 0.40 | 0.35 | 0.01 | 0.01 |
| | Mob.Lab. | x | 5.2 | 58.9 | 1.9 | 12.1 | 15929 | 14.7 | 9.4 | 2.465 | 2.513 |
| | n = 22 | σ | 0.17 | 1.97 | 0.44 | 1.00 | 1203 | 0.62 | 0.24 | 0.01 | 0.01 |

## SUMMARY OF PLANT CHECKS

### EASTERN REGION

| | | | A.C. | SAND | VOIDS | FLOW | STAB. | V.M.A. | % PASS 200 IN SAND | B.S.G. | M.S.G. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 80-28 | Mob.Lab. | $\bar{x}$ | 4.9 | 54.3 | 1.9 | 13.7 | 3251 | 14.1 | 8.4 | | |
| 50:50 | n = 20 | $\sigma$ | 0.29 | 2.98 | 0.55 | 1.68 | 476 | 0.58 | 1.13 | | |
| 80-25 | Mob.Lab. | $\bar{x}$ | 5.1 | 61.1 | 2.3 | 13.6 | 2990 | 15.4 | 8.9 | 2.546 | 2.607 |
| 70:30 | n = 33 | $\sigma$ | 0.42 | 5.07 | 0.58 | 1.47 | 532.7 | 0.90 | 1.24 | 0.024 | 0.222 |
| 79-23 | Reg.Lab. | $\bar{x}$ | 4.9 | 63.5 | 2.4 | 17.5 | 3046 | 14.3 | 8.3 | 2.445 | 2.505 |
| 70:30 | n = 29 | $\sigma$ | 0.25 | 3.00 | 0.61 | 1.44 | 271 | 0.64 | 0.98 | 0.013 | 0.008 |
| | Mob.Lab. n = 5 | $\bar{x}$ | 5.3 | 58.2 | 1.7 | 20.8 | 2822 | 15.4 | 7.7 | 2.464 | 2.507 |
| 81-74 | Reg.Lab. | $\bar{x}$ | 5.2 | 57.5 | 2.8 | 12.1 | 14469 | 14.8 | 4.8 | | |
| 50:50 | n = 22 | $\sigma$ | 0.34 | 2.69 | 1.07 | 1.03 | 23 | 0.90 | 0.59 | | |
| 81-16 | RAP #1 | | 5.5 | 55.8 | 3.5 | 7.9 | 8878 | 15.2 | 2.9 | | |
| 30:70 | n = 35 | | 0.18 | 1.67 | 0.65 | 0.70 | 1827 | 0.43 | 0.45 | | |
| | RAP #2 | | 5.7 | | 2.6 | 8.3 | 8540 | 15.0 | 2.8 | | |
| | n = 20 | | 0.23 | | 0.84 | 0.92 | 1208 | 0.64 | 0.41 | | |

## SUMMARY OF PLANT CHECKS

### CENTRAL REGION

| | | A.C. | SAND | VOIDS | FLOW | STAB. | V.M.A. | % PASS 200 IN SAND | B.S.G. | M.S.G. |
|---|---|---|---|---|---|---|---|---|---|---|
| 82-20 | | 5.6 | 57.0 | 1.0 | 17.9 | 12949 | 14.8 | 5.18 | 2.458 | 2.484 |
| 40:60 | n = 19 | 0.25 | 3.45 | 0.4 | 1.98 | 726 | 0.53 | 0.42 | 0.007 | 0.008 |
| 82-19 | | 5.4 | 53.2 | 1.0 | 14.2 | 12086 | 14.3 | 4.09 | 2.461 | 2.486 |
| 30:70 | n = 14 | 0.25 | 2.27 | 0.43 | 1.82 | 1212.3 | 0.58 | 0.73 | 0.007 | 0.011 |
| 81-100 | | 5.3 | 58.6 | 1.5 | 14.2 | 13578 | 14.6 | 4.66 | 2.460 | 2.499 |
| 70:30 | n = 11 | 0.28 | 1.52 | 0.49 | 1.26 | 1560.s | 0.53 | 0.30 | 0.008 | 0.017 |
| 81-71 | | 4.9 | 59.9 | 1.6 | 15.9 | 14359 | 13.8 | 9.9 | 2.468 | 2.538 |
| 50:50 | n = 20 | 0.41 | 5.34 | 1.47 | 3.45 | 3213 | 0.94 | 1.46 | 0.027 | 0.019 |
| 81-88 | | 5.2 | 54.3 | 1.7 | 15.2 | 11196 | 14.7 | 8.24 | 2.485 | 2.557 |
| 40:60 | n - 14 | 0.65 | 5.26 | 1.57 | 1.45 | 2128 | 1.05 | 0.90 | 0.032 | 0.043 |
| 82-59 | | 5.2 | 54.1 | 1.2 | 17.4 | 12593 | 14.1 | 9.1 | 2.481 | 2.529 |
| 50:50 | n = 37 | 0.37 | 2.68 | 0.68 | 2.36 | 2012 | 0.87 | 0.98 | 0.019 | 0.011 |
| 81-86 | | 5.2 | 53.1 | 2.3 | 16.6 | 11802 | 15.4 | 10.1 | 2.515 | 2.576 |
| 47:53 | B n = 33 | 0.23 | 3.50 | 0.71 | 2.13 | 1654 | 0.81 | 0.75 | 0.026 | 0.21 |
| 25:75 | S n = 21 | 5.8 | 56.1 | 1.7 | 19.9 | 14085 | 18.2 | 8.3 | 2.831 | 2.879 |
| | | 0.21 | 3.03 | 0.52 | 1.50 | 1413 | 0.49 | 0.58 | 0.030 | 0.029 |

## SUMMARY OF PLANT CHECKS

### SOUTH WESTERN REGION

| | | | A.C. | SAND | VOIDS | FLOW | STAB. | V.M.A. | % PASS 200 IN SAND | B.S.G. | M.S.G. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 82-38 | | | 5.5 | 61.3 | 3.2 | 10.9 | 14035 | 16.6 | 7.6 | | |
| 50:50 | n = 43 | | 0.26 | 2.53 | 0.96 | 1.72 | | 0.71 | 0.73 | | |
| 82-04 | | | 5.6 | 64.7 | 1.9 | 13.5 | 17658 | 15.3 | 8.8 | | |
| 70:30 | n = 73 | | 0.33 | 2.84 | 0.83 | 2.10 | | 0.84 | 0.53 | | |
| 82-43 | | | 5.6 | 59.0 | 3.2 | 11.9 | 14618 | 16.5 | 7.0 | | |
| 40:60 | n - 21 | | 0.27 | 3.60 | 0.97 | 1.27 | | 1.12 | 1.08 | | |
| 82-69 | | | 5.4 | 61.6 | 2.2 | 13.1 | 16256 | 15.4 | 8.1 | | |
| 50:50 | n = 18 | | 0.29 | 3.06 | 0.92 | 0.92 | | 0.69 | 0.80 | | |
| 81-10 | Binder | | 5.6 | 65.7 | 1.6 | 16.8 | 14680 | 15.1 | 11.0 | | |
| 70:30 | n = 33 | | 0.44 | 3.42 | 0.98 | 3.30 | | 1.09 | 1.35 | | |
| 60:40 | Surface | | 5.6 | 66.4 | 2.0 | 11.3 | 13159 | 15.7 | 8.7 | | |
| | n = 20 | | 0.15 | 2.49 | 0.52 | 1.39 | | 0.60 | 0.91 | | |
| 82-06 | | | 5.3 | 62.3 | 1.7 | 11.4 | 11815 | 14.7 | 6.8 | | |
| 40:60 | n = 25 | | 0.15 | 2.24 | 0.60 | 0.88 | | 0.53 | 0.72 | | |
| 82-13 | Binder | x | 5.3 | 65.1 | 2.2 | 12.0 | 15958 | 15.1 | 6.8 | | |
| 45:55 | n = 17 | σ | 0.19 | 1.78 | 0.54 | 1.14 | | 0.52 | 1.32 | | |

Compiled by R.C. Evers